SCIENCE AND TECHNOLOGY TEXT MINING: WIRELESS LANS

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ABSTRACT

Database Tomography (DT) is a textual database analysis system consisting of two major components: 1) algorithms for extracting multi-word phrase frequencies and phrase proximities (physical closeness of the multi-word technical phrases) from any type of large textual database, to augment 2) interpretative capabilities of the expert human analyst. DT was used to obtain technical intelligence from a Wireless LAN (Local Area Network) database derived from the Science Citation Index/ Social Science Citation Index (SCI). Phrase frequency analysis by the technical domain experts provided the pervasive technical themes of the Wireless LAN database, and the phrase proximity analysis provided the relationships among the pervasive technical themes. Bibliometric analysis of the Wireless LAN literature supplemented the DT results with author/ journal/ institution publication and citation data.

EXECUTIVE SUMMARY

A study was performed to identify the structure and infrastructure of the Wireless LANs literature. An extensive query was developed to retrieve the Wireless LANs research literature, as represented in the Science Citation Index, for different time frames. For this retrieved literature, bibliometrics (counting of papers, citations, etc.) was performed to generate the infrastructure (prolific authors, Centers of Excellence, etc.) of the Wireless LANs literature, and computational linguistics (grouping of phrases, similar documents) was performed to generate the technical structure (pervasive technical themes, relationships among themes) of the Wireless LANs literature. Included in the bibliometrics results was identification of the seminal papers of the Wireless LANs literature.

<u>Bibliometrics Results</u>

Of the twenty most prolific authors from 1991 to mid-2002, ten are from Japan. In fact, twelve are from Asia, four are from Europe (Western), and four are from North America. Ten are from universities, seven are from private industry, and three are from research institutes. These prolific author results show that private industry contains a substantial portion of the most prolific WLAN research and development authors, reflecting the more applied research nature of much of the reported work. Additionally, from the mid-90s to mid-2002, there was an approximately linear increase in papers published, at about the rate of 100 papers per year.

In an update of the most prolific authors performed immediately prior to publication of this report, it was shown that, for the years 2004 to mid-2005, all but two of the most prolific authors had names of apparent Asian origin. The significance of this finding will be made more explicit in the update of most prolific countries.

The majority of the journals containing the most Wireless LANs papers from 1991 to mid-2002 are focused on communications, with the remainder divided between networking and electronics. Bradford's Law allows journals to be divided into groups, with each group containing roughly similar numbers of publications, and the ratio of the number of journals in each adjacent group equaling a constant. There appear to be two primary groups at the top layer. The *IEEE Journal on Selected Areas in Communications* contains the most articles by far and, along with the Journal of the *IEICE Transactions on Communications* and *IEEE Transactions on Vehicular Technology*, constitutes the first group. The next group consists of

Electronics Letters, IEEE Transactions on Communications, IEEE Communications Magazine, IEICE Transactions on Fundamentals of Electronics Communications and Computer Sciences, Microwaves & RF, IEEE Personal Communications, and *Wireless Networks*.

While *IEEE Transactions on Vehicular Technology* may seem out of place, this journal publishes many papers dealing with electrical and electronics technology in vehicles and vehicular systems. The areas of communications, transportation systems, and vehicular electronics define its scope.

The journals were also updated for 2004 to mid-2005. Of the 21 journals pre-2003, and the 19 journals post-2003 listed, ten were in common. Of those not shared, many of the recent papers appear in journals whose titles suggest a wireless focus and a mobile networking focus. Because of the technology specificity, these more recent papers have even more of an applications focus than what was perceived as an already quite applied discipline.

Of the twenty most prolific institutions from 1991 to mid-2002, ten are from Asia, five are from Western Europe, four from the USA, and one from Eastern Europe. Ten are universities, eight are privately owned businesses and the remaining institutions are research institutes. These distributions reflect those of the most prolific authors, and confirm the substantial contribution of the private sector in the time frame identified.

The institutions were also updated for 2004 to mid-2005. For the 2004 to mid-2005 results, there was a shift in the most prolific institutions from mainly USA to Asian. Also, none of the industrial organizations (that were so prominent in the 1991 to mid-2002 results) appear in the latest results. This absence of industry can be seen more dramatically by examining the results from the period 1991-1995 only. Over 25% of the prolific institutions in this early time frame are industrial organizations.

There appear to be three dominant groups in the twenty most prolific countries from 1991 to mid-2002. The USA is in a group of its own, with more than twice the number of papers as the next most prolific country. Japan constitutes the second most dominant group with substantially more papers than the third most prolific country. The sum of papers from the US and Japan almost surpasses the cumulative sum of the proceeding eighteen most prolific countries. South Korea, Italy, Germany, Taiwan, England and Canada make up the third most prolific group. Of the eleven most prolific countries, five are Asian, confirming the prolific author and institution results. With the exception of perhaps China, the developing nations are playing almost no role in the literature contribution of Wireless LANs.

Temporal trends of country publications from 1991 to mid-2002 show that there has been a dramatic increase in the number of publications that different countries have produced, dealing with Wireless LANs. The most notable increase has been within the United States. Japan, having less of an increase than the United States, still has had an increase in publications that well surpasses any of the other countries over the 1991 to mid-2002 time period.

In terms of absolute numbers of co-authored papers from 1991 to mid-2002, the USA major partners were Italy, Japan, Canada, and South Korea. Of the top 15 countries publishing Wireless LAN papers, most did not have a substantial amount of inter-country published papers. In cases where there was inter-country publishing, it typically was with countries in similar geographical regions. The US was perhaps the exception – co-publishing with many other countries from various geographical regions.

The country results were also updated for 2004 to mid-2005. There has been a major shift in country emphasis in the past decade. Except for the USA, the Western nations' leadership has been replaced by that of the Asian nations. Especially large advances have been made by South Korea (7% of USA paper production a decade ago to 43% of USA production presently), Taiwan (3% of USA to 29% of USA), and Peoples Republic of China (1% of USA to 25% of USA).

Of the twenty most cited first authors for the 1991 to mid-2002 database, seventeen are from North America (USA), two are from Asia (Japan), and one is from Europe (Italy). This is a far different distribution from the most prolific authors, where twelve were from Asia (Far East). There are a number of potential reasons for this difference, including difference in quality and late entry into the Wireless LANs research discipline. In another three or four years when the papers from present-day authors have accumulated sufficient citations, firmer conclusions about quality can be drawn.

The lists of twenty most prolific authors and twenty most highly cited first authors for the 1991 to mid-2002 database had only two names in common (ADACHI, ZORZI). This phenomenon of minimal intersection has been observed in all other text mining studies performed by the first author of the present report. The time frame of interest for most prolific authors is present time, whereas the time frame of interest for most cited can span many decades. Researchers who may very well have been prolific when their most citable work was done may no longer be prolific. Finally, many prolific authors, especially at academic institutions, tend not to be first authors in most of their publications. Therefore, they tend to be severely under-represented in the SCI citation downloads, which contain first authors only.

Twelve of the top twenty cited authors' institutions are universities, and five are private companies. This differs a bit from the most prolific authors in that the distribution between universities and privately owned businesses is ten to seven, respectively.

The main focal points of the majority of the most highly-cited papers from the 1991 to mid-2002 database are CDMA (Code-Division Multiple Access) and other protocols within Wireless LANs. There are a number of other topics addressed within the papers as well, including data transmission and throughput in ATM (Asynchronous Transfer Mode) networks and Spread Spectrum technology, Network Architecture, and a broader group that focuses on different applications for Wireless Networks. These focal points correlate well with the themes resulting from the computational linguistics (clustering), as will be shown later.

The list of most cited journals from the 1991 to mid-2002 database is very similar to the list of most prolific journals, although some items are not in the same order.

Computational Linguistics Results

The technical structure of the Wireless LANs literature is presented as a hierarchical taxonomy. For taxonomy generation, a combined factor matrix and multi-link word clustering process was developed and used for the first time. The factor matrix served to filter the words input to the clustering algorithm, identified the context-dependent trivial words to be excluded, and identified the context-dependent words that could be conflated. In addition, document clustering algorithms based on Greedy String Tiling text similarity quantification and Partitional Document Clustering (Objective Function Optimization) were developed and used for the first time.

The major total database theme (1991 to mid-2002 records) is research on methods to improve throughput while maintaining Quality-of-Service. In all three clustering approaches used in this study, the top-level categorization appeared to consist of two moderately distinct categories. One (Improved Throughput from Physical Layer Advances) addresses digital spread spectrum modulation techniques (CDMA) to increase throughput and user capacity, and the associated efforts at the physical layer to reduce inherent interference limitations of CDMA on system capacity. The other (Improved Throughput from Protocols and Architectures) covers Network Architecture and Applications designed to improve throughput, including infrastructure, protocols, hardware and applications.

Level 1

IMPROVED THROUGHPUT FROM PHYSICAL LAYER ADVANCES

Reduction of multiple access interference suppression in the spatial domain and in the code domain for CDMA systems, and physical approaches to reduce fading losses and restore signal degradation that occurred at the physical layer.

IMPROVED THROUGHPUT FROM PROTOCOLS AND ARCHITECTURES

Protocols for mobile wireless voice and data traffic ATM networks to avoid packet collisions, reduce call dropping, reduce delays, and increase throughput while maintaining Quality of Service.

At the next categorization level, four categories can be discerned. These categories (underlined), and their key themes (bulletized) are as follows:

Level 2

SIGNAL QUALITY MAINTENANCE

Signal degradation at the physical layer, and use of electronics technology to restore and maintain signal quality.

- Optical wave reflections off walls and columns inside buildings, and propagation measurements

- Antennas, especially micro-strip patch and other arrays, and simulated/ measured beam radiation patterns for reduced electromagnetic interference

- Power amplifiers in the Ghz frequency range for wireless LANs, especially those using CMOS hardware or circuitry

CDMA INTERFERENCE REDUCTION

<u>Reduction of multiple access interference suppression in the spatial domain and in the code domain for CDMA systems, and physical approaches to reduce fading losses</u>

- OFDM (Orthogonal Frequency-Division Multiplexing), especially degradation from frequency offsets, and symbol modification to cut down on ISI (Inter-Symbol Interference) while benefiting from reduced path loss

- Use of DS\CDMA (Direct-Sequence\ Code-Division Multiple Access) systems that improve BER (Bit Error Rate) within Rayleigh multi-path fading channels.

- Diversity, by the use of antenna diversity reception and coherent Rake combiners, in spread-spectrum communications over fast-fading multi-path channels for increasing throughput

- Channel estimation for interference-limited channels, and multi-user detectors for co-channel interference cancellation

- CDMA (Code-Division Multiple Access) to increase system capacity by reducing interference from other users in a cell

- Use of signal-to-interference power ratio (SIR) measurement based fast transmit power control (TPC) to reduce the minimum transmit power according to the channel load and the changes in the link conditions due to fading

PACKET TRAFFIC PROTOCOLS

<u>Access protocols for voice and data traffic that increase throughput and reduce delays by packet collision avoidance (e.g., CSMA).</u>

- TCP (Transmission Control Protocols) employing ARQ/FEC (Automatic Repeat Request/Forward Error Correction) protocols, to reduce packet error

- MAC (Medium Access Control) Protocols, especially TDMA-based, that efficiently accommodate real-time voice and video traffic with dynamic bandwidth/ resource allocation

- Access protocols for integrated voice and data traffic that overcome the heavy load degraded performance due to the contention mechanism of random access in PRMA (Packet Reservation Multiple Access) protocols.

- CSMA (Carrier-Sense Multiple Access) protocols that increase throughput by focusing on packet collision avoidance

NETWORK ARCHITECTURES

Architectures and routing protocols for mobile ad hoc wireless ATM networks to improve Quality of Service.

- Standard IEEE 802.11 MAC (Medium Access Control) protocols for wireless LANs

- Standard Bluetooth IEEE 802.11 wireless LAN devices and technology

- Providing Internet services, with enhanced performance Internet protocols over wireless networks, to mobile communications systems users

- Architectures maintaining guaranteed levels of QoS (Quality of Service) within wireless mobile ATM (Asynchronous Transfer Mode) networks

- Handoffs and connection path rerouting to avoid cell loss to mobile users in ATM (Asynchronous Transfer Mode) networks

- Call handoff management schemes to minimize dropping probability of handoff calls and blocking probability of new calls

- Routing protocols for wireless ad hoc mobile networks

- Multicasting, especially in mobile ad hoc networks with multiple hosts, and the use of multicast delivery trees under mobile host conditions

Approximately 46% of the CLUTO (the software package for generating the partitional document clusters) cluster documents are assigned by the clustering algorithm to the first higher level category, Improved Throughput from Physical Layer Advances, while the other 54% are assigned to the second higher level category, Improved Throughput from Protocols and Architectures. The category Improved Throughput from Physical Layer Advances breaks into two second level categories, with 30% of its documents assigned to the category Signal Quality Maintenance, and 70% assigned to category CDMA Interference Reduction. The other first level cluster, Improved Throughput from Protocols and Architectures, also divides into two second level groups, with 36% of its documents assigned to category Packet Traffic Protocols, and 64% of its records assigned to category Network Architectures.

Finally, the systematic method of Citation-Assisted Background was used to identify the seminal literature of Wireless LANs. The most cited references in the retrieved Wireless LANs database covering 1991 to mid-2005 are tabulated in order of inverse frequency. Documents with citations above some threshold frequency are tagged. Then, the table is re-ordered chronologically. The early historical documents with citation frequencies substantially larger than those of their contemporaries are selected, as are the extremely recent documents with citation frequencies substantially larger than those of their contemporaries. By contemporaries, it is meant documents published in the same time frame, not limited to the same year (see next paragraph for examples of how we implement 'same time frame'). Then, the dynamic selection process defined above is applied to the early historical references, the intermediate time references (those falling under the high frequency threshold), and the extremely recent references (approximately two years or less).

There were a total of 133 documents selected as seminal. While the earliest seminal documents in the physical sciences literatures the first author has examined previously were published in the 18th and 19th centuries, the earliest seminal document identified in the present Wireless LANs analysis is Shannon's classic 1948 paper(s) on the mathematical theory of communication.

Although the journals associated with these seminal papers cover many aspects of communication, three stand out in terms of numbers of seminal papers published. From 1948-1969 (with an outlier in 1996), the Bell System Technical Journal published eight of these seminal papers. From 1975-1994 (with an outlier in 1998), the IEEE Transactions on Communications published 19 of these seminal papers. From 1993-2000 (with an outlier in 1987), the IEEE Journal on Selected Areas in Communications published 15 of these seminal papers.

Each of these three journals commanded essentially a separate time frame, with each time frame appearing approximately sequentially.

1. INTRODUCTION

Science and technology are assuming an increasingly important role in the conduct and structure of domestic and foreign business and government. In the highly competitive civilian and military worlds, there has been a commensurate increase in the need for scientific and technical intelligence to insure that one's perceived adversaries do not gain an overwhelming advantage in the use of science and technology. While there is no substitute for direct human intelligence gathering, there have become available many techniques that can support and complement it. In particular, techniques that identify, select, gather, cull, and interpret large amounts of technological information semi-automatically can expand greatly the capabilities of human beings in performing technical intelligence.

One such technique is DT [Kostoff 1993, 1994, 1995], a system for analyzing large amounts of textual computerized material. It includes algorithms for extracting multi-word phrase frequencies and phrase proximities from the textual databases, coupled with the topical expert human analyst to interpret the results and convert large volumes of disorganized data to ordered information. Phrase frequency analysis (occurrence frequency of multi-word technical phrases) provides the pervasive technical themes of a database, and the phrase proximity (physical closeness of the multi-word technical phrases) analysis provides the relationships among pervasive technical themes, as well as among technical themes and authors/ journals/ institutions/ countries, etc. The present report describes use of the DT process, supplemented by literature bibliometric analyses, to derive technical intelligence from the published literature of Wireless LAN technology.

Wireless LANs, as defined by the authors for this study, allow mobile or stationary users to connect to a local area network (LAN) through wireless radio or infrared connections. Since one of the key outputs of the present study is a query that can be used by the community to access relevant Wireless LANs documents, a recommended query based on this study is presented in total. This query serves as the operational definition of Wireless LANs, and its development is discussed in detail in the database generation section.

<u>WIRELESS LANs QUERY</u>
(WIRELESS SAME (LAN OR LANS OR IP OR HIPERLAN OR SPREAD SPECTRUM OR SPREAD-SPECTRUM OR MEDIUM ACCESS CONTROL OR CDMA OR PROTOCOL* OR ATM OR TDMA OR OFDM OR ASYNCHRONOUS TRANSFER MODE OR MODEM OR MANET OR LOCAL AREA NETWORK* OR MULTIPATH OR CSMA)) OR WLAN* OR (MOBIL*

SAME (LAN OR LANS OR MEDIUM ACCESS CONTROL OR INTERNET PROTOCOL OR ATM OR RSVP OR TCP IP OR CDMA OR CSMA)) OR (MAC SAME CSMA) OR AD HOC NETWORK* OR BLUETOOTH OR CSMA CA OR CSMA-CA OR CSMA CD OR CSMA-CD OR HIPERLAN OR DISTRIBUTED COORDINATION FUNCTION OR WIRELESS PERSONAL AREA NETWORK* OR WPAN OR WPANS OR IEEE 802.11

To execute the study reported in this paper, a database of relevant Wireless LAN articles is generated using the iterative search approach of Simulated Nucleation [Kostoff et al, 1997a, 2001a]. Then, the database is analyzed to produce the following characteristics and key features of the Wireless LAN field: recent prolific Wireless LAN authors; journals that contain numerous Wireless LAN papers; institutions that produce numerous Wireless LAN papers; keywords most frequently specified by the Wireless LAN authors; authors, papers and journals cited most frequently; pervasive technical themes of Wireless LANs; and relationships among the pervasive themes and sub-themes.

What is the importance of applying DT and bibliometrics to a topical field such as Wireless LANs? The roadmap, or guide, of this field produced by DT and bibliometrics provides the demographics and a macroscopic view of the total field in the global context of allied fields. This allows specific starting points to be chosen rationally for more detailed investigations into a specific topic of interest. DT and bibliometrics do not obviate the need for detailed investigation of the literature or interactions with the main performers of a given topical area in order to make a substantial contribution to the understanding or the advancement of this topical area, but allow these detailed efforts to be executed more efficiently. DT and bibliometrics are quantity-based measures (number of papers published, frequency of technical phrases, etc.), and correlations with intrinsic quality are less direct. The direct quality components of detailed literature investigation and interaction with performers, combined with the DT and bibliometrics analysis, can result in a product highly relevant to the user community.

2. BACKGROUND

Text Mining

Text mining is the extraction of useful information from large volumes of text. Its component capabilities of computational linguistics and bibliometrics were the main analytical techniques used for the present study, and these capabilities can be summarized as follows.

Science and technology (S&T) computational linguistics [Kostoff, 2003a; Hearst, 1999; Zhu and Porter, 2002; Losiewicz, 2000] is a process that underlies the extraction of useful information from large volumes of technical text. It identifies pervasive technical themes in large databases from technical phrases that occur frequently. It also identifies relationships among these themes by grouping (clustering) these phrases (or their parent documents) on the basis of similarity. Computational linguistics can be used for:

- Enhancing information retrieval and increasing awareness of the global technical literature [Kostoff et al, 1997a; Greengrass, 1997; TREC, 2003]
- Potential discovery and innovation based on merging common linkages among very disparate literatures [Swanson, 1986; Swanson and Smalheiser, 1997; Kostoff, 2003b; Gordon and Dumais, 1998]
- Uncovering unexpected asymmetries from the technical literature [Goldman et al, 1999; Kostoff, 2003c]
- Estimating global levels of effort in S&T sub-disciplines [Kostoff et al, 2000a, 2004a; Viator and Pestorius, 2001]
- Helping authors potentially increase their citation statistics by improving access to their published papers, and thereby potentially helping journals to increase their Impact Factors [Kostoff et al, 2004a, 2004b]
- Tracking myriad research impacts across time and applications areas [Davidse and Van Raan, 1997; Kostoff et al, 2001b].

Evaluative bibliometrics [Narin, 1976; Garfield, 1985; Schubert et al, 1987] uses counts of publications, patents, citations and other potentially informative items to develop science and technology performance indicators. Its validity is based on the premises that 1) counts of patents and papers provide valid indicators of R&D activity in the subject areas of those patents or papers, 2) the number of times those patents or papers are cited in subsequent patents or papers provides valid indicators of the impact or importance of the cited patents and papers, and 3) the citations from papers to papers, from patents to patents and from patents to papers provide indicators of intellectual linkages between the organizations which are producing the patents and papers, and knowledge linkage between their subject areas [Narin et al, 1994]. Evaluative bibliometrics can be used to:

- Identify the infrastructure (authors, journals, institutions) of a technical domain,
- Identify experts for innovation-enhancing technical workshops and review panels,

- Develop site visitation strategies for assessment of prolific organizations globally,
- Identify impacts (literature citations) of individuals, research units, organizations, and countries

A typical text mining study of the published literature develops a query for comprehensive information retrieval, processes the retrieved database using computational linguistics and bibliometrics, and integrates the processed information.

2.2 Unique and Advanced Study Features

The study reported in the present paper is in the journal article abstract category. It differs from the previous published papers in this category [Kostoff et al, 1997b, 1998a, 1999a, 2000a, 2000b, 2002, 2004a, 2004b] in three respects. First, the topical domain (Wireless LANs) is completely different. Second, document clustering techniques for theme categorization, based on Greedy String Tiling (see Appendix 1 for more details) [Wise, 1992] and Clustering Objective Function Optimization (see Appendix 2 for more details) [Zhao and Karypis, 2004] for text similarity, were developed and included, to complement the word/ concept clustering approach. Third, factor matrix filtering was developed and used to select context-dependent words for input to the clustering algorithm, thereby leading to more sharply defined clusters. In addition, bibliometric clustering is presented for two database fields: authors and countries Finally, the marginal utility algorithm for query term truncation was applied, allowing only the highest payoff terms to be included in the final query, and resulting in an efficient query.

3. DATABASE GENERATION

The key step in the Wireless LAN literature analysis is the generation of the database to be used for processing. There are three main elements to database generation: the overall objectives, the approach selected, and the database used. Each of these elements is described.

3.1 Overall Study Objectives

The main objective was to identify global S&T that had both direct and indirect relations to Wireless LANs. A sub-objective was to estimate the overall level of global effort in Wireless LAN technology, as reflected by the emphases in the published literature.

3.2 Databases and Approach

For the present study, the SCI database (including both the Science Citation Index and the Social Science Citation Index) was used. The approach used for query development was the DT-based iterative relevance feedback concept [Kostoff et al, 1997a].

3.2.1 Science Citation Index/ Social Science Citation Index (SCI) [SCI, 2002]

The retrieved database used for analysis consists of selected journal records (including the fields of authors, titles, journals, author addresses, author keywords, abstract narratives, and references cited for each paper) obtained by searching the Web version of the SCI for Wireless LAN articles. At the time the final data was extracted for the baseline analysis in the present report (mid-2002), the version of the SCI used accessed about 5600 journals (mainly in physical, engineering, and life sciences basic research) from the Science Citation Index, and over 1700 journals from the Social Science Citation Index.

The SCI database selected represents a fraction of the available Wireless LAN (mainly research) literature, that in turn represents a fraction of the Wireless LAN S&T actually performed globally [Kostoff, 2000c]. The articles contained within the SCI database do not include the large body of classified literature, or company proprietary technology literature, although the SCI articles could reference these literatures. The SCI articles do not include technical reports, books, or patents on Wireless LANs, but could again reference these literatures. For the computational linguistics and much of the bibliometrics, the SCI covers a finite slice of time (1999 to mid-2002). The database used represents the bulk of the peer-reviewed high quality Wireless LAN research literature, and is a representative sample of all Wireless LAN research in recent times.

To extract the relevant articles from the SCI, the Title, Keyword, and Abstract fields were searched using Keywords relevant to Wireless LANs. The resultant Abstracts were culled to those relevant to Wireless LANs. The search was performed with the aid of two powerful DT tools (multi-word phrase frequency analysis and phrase proximity analysis) using the process of Simulated Nucleation [Kostoff et al, 1997a].

An initial query of Wireless LAN-related terms produced two groups of papers: one group was judged by domain experts to be relevant to the subject matter, the other was judged to be non-relevant. Gradations of relevancy or non-relevancy were not considered. An initial database of Titles, Keywords, and Abstracts was created for each of the two groups of papers. Phrase frequency and proximity analyses were performed on this textual database for each group. The high frequency single, double, and triple word phrases characteristic of the relevant group, and their boolean combinations, were then added to the query to expand the papers retrieved. Clustering of phrases into thematic categories was performed to help guide the selection of phrases. Phrases from each of the thematic categories were selected to insure balanced category representation from the complete sample of relevant records. Similar phrases characteristic of the non-relevant group are ordinarily subtracted from the query to contract the papers retrieved, but the terms used in the present study were sufficiently focused that all documents retrieved were relevant. The process was repeated on the new database of Titles, Keywords, and Abstracts obtained from the search. A few more iterations were performed until the number of records retrieved stabilized (convergence). The final phrase-based query used for the Wireless LAN study was shown in the Introduction.

In order to generate an efficient final query, a new process termed Marginal Utility was applied. At the start of the final iteration, a modified query Q1 was inserted into the SCI, and records were retrieved. Each term in Q1 was inserted into the Marginal Utility algorithm, and the marginal number of records in the sample that the query term would retrieve was computed. Only those terms that retrieved a substantial number of additional records were retained. Since (by design) each query term had been used to retrieve records from the SCI as part of Q1, the marginal ratio of additional new records from the sample would represent the marginal ratio of additional new records from the SCI. The final efficient query Q2, consisting of the highest marginal utility terms, was shown in the Introduction.

In the Marginal Utility algorithm, terms that co-occur strongly in records with previously-selected terms are essentially duplicative from the retrieval perspective, and can be eliminated. Thus, the order in which terms are selected becomes important. An automated query term selection algorithm using Marginal Utility is being developed that will examine all ordering combinations, in order to identify the most efficient query.

The authors believe that queries of these magnitudes and complexities are required when necessary to provide a tailored database of relevant records that encompasses the broader aspects of target disciplines. In particular, if it is desired to enhance the transfer of ideas across disparate disciplines, and thereby stimulate the potential for innovation and discovery from complementary literatures [Kostoff, 1999b, 2003b, 2005a], then even more complex queries using Simulated Nucleation may be required.

4. RESULTS

The results from the publications bibliometric analyses and citations bibliometrics analysis are presented in section 4.1, followed by the results from the DT analyses in section 4.2. The SCI bibliometric fields incorporated into the database included, for each paper, the author, journal, institution, and Keywords. In addition, the SCI included references for each paper.

The bibliometrics section (4.1) has three components. Some numerical indicators are presented for each bibliometric examined. Clustering results, that portray cohesive groups, are presented for most prolific authors only. Finally, the highest frequency bibliometrics (e.g., most prolific author, most prolific country) are presented for each bibliometric, and discussed.

The DT section (4.2) has two major statistical clustering components: concept and document clustering. The concept clustering groups words and phrases to identify the major thematic categories of the database primarily, but has the capability to estimate levels of emphasis in each thematic category by counting phrase frequencies. The document clustering groups and counts documents to identify the levels of emphasis in each thematic category primarily, but has the capability to identify the major thematic categories by phrase extraction.

4.1 Bibliometric Results

The first group of metrics presented is counts of papers published by different entities. These metrics can be viewed as output and productivity measures. They are not direct measures of research quality, although there is some threshold quality level inferred, since these papers are published in the (typically) high caliber journals accessed by the SCI.

These more recent DT/ bibliometrics studies were conducted of the technical fields of: 1) Near-earth space (NES) [Kostoff et al, 1998a]; 2) Hypersonic and supersonic flow over aerodynamic bodies (HSF) [Kostoff et al, 1999a]; 3) Chemistry (JACS) [Kostoff et al, 1997b] as represented by the Journal of the American Chemical Society; 4) Fullerenes (FUL) [Kostoff et al; 2000b] 5) Aircraft (AIR) [Kostoff et al, 2000a]; 6) Hydrodynamic flow over surfaces (HYD); 7) Electric Power Sources (EPS) [Kostoff et al, 2005b]; 8) Electrochemical Power Sources (ECHEM)

[Kostoff et al, 2002] 9) the non-technical field of research impact assessment (RIA) [Kostoff et al, 1997b]; 10) NonLinear Dynamics (NONLIN) [Kostoff et al, 2004a] and Fractals (FRACT) [Kostoff et al, 2004b]. Overall parameters of these studies from the SCI database results and the current Wireless LAN study are shown in Table 1.

TABLE 1 - DT STUDIES OF TOPICAL FIELDS

TOPICAL AREA	NUMBER OF SCI ARTICLES	YEARS COVERED
1) NEAR-EARTH SPACE (NES)	5480	1993-MID 1996
2) HYPERSONICS (HSF)	1284	1993-MID 1996
3)CHEMISTRY (JACS)	2150	1994
4) FULLERENES (FUL)	10515	1991-MID 1998
5) AIRCRAFT (AIR)	4346	1991-MID 1998
6) HYDRODYNAMICS (HYD)	4608	1991-MID 1998
7) ELECTRIC POWER SOURCES (EPS)	20835	1991-BEG 2000
8) ELECTROCHEMICAL POWER SOURCES (ECHEM)	6985	1993 – MID 2001
9) RESEARCH ASSESSMENT (RIA)	2300	1991-BEG 1995
10) NONLINEAR DYNAMICS (NONLIN)	6118 (2001)	1991, 2001
11) FRACTALS (FRACT)	4454 (2001-02); 4211 (1991-93)	1991-93, 2001-02
12) WIRELESS LANS (WLANS)	2328	(1991- MID 2002)

These studies yielded: 1) 3.37 authors per paper for the NES results; 2) 2.63 authors per paper for the HSF results; 3) 3.79 authors per paper for the JACS results; 4) 3.92 authors per paper for the FUL results; 5) 2.09 authors per paper for the AIR results; 6) 2.29 authors per paper for the HYD results; 7) 2.90 authors per paper for the EPS results; 8) 3.65 authors per paper for the ECHEM results. 9) 1.68 authors per paper for the RIA results; 10) 2.68 authors per paper for the NONLIN results; and 11) 2.86 authors per paper for the FRACT results.

In the present Wireless LANs study, two types of computational linguistics analysis were performed on the author data field in the database. First, a frequency count of author appearances was made from the author field in the database, to identify the most prolific authors. Second, a clustering analysis was performed on the list of author appearances, to identify tightly-knit multi-author groups. The clustering methodology (also used in the analysis of the Abstract free text field to generate technology taxonomies) is described in Appendix 3.

4.1.1 Prolific Wireless LANs Authors

For the period 1991 to mid-2002, there were 2328 papers retrieved, 4065 different authors, and 6286 author listings. The occurrence of each author's name on a paper is defined as an author listing. While the average number of listings per author is about 1.5, the twenty most prolific authors (see Table 2) have listings more than an order of magnitude greater than the average. The number of papers listed for each author are those in the database of records extracted from the SCI using the query, not the total number of author papers listed in the source SCI database.

4.1.1.1 Author Frequency Results

TABLE 2 – MOST PROLIFIC AUTHORS – 1991-MID-2002
(present institution listed)

AUTHOR NAME	INSTITUTION	COUNTRY	TECHNICAL KEYWORDS	# OF PAPERS
ADACHI, F	Tohoku Univ	Japan	DS-CDMA; MOBILE RADIO; RAKE COMBINING;	51
SAWAHASHI, M	NTT DoCoMo Inc	Japan	DS-CDMA; MOBILE RADIO; ADAPTIVE ANTENNA ARRAY;	40
FANTACCI, R	Univ Florence	Italy	RESERVATION MULTIPLE ACCESS; PCN; SATELLITE SYSTEMS;	16
MILSTEIN, LB	Univ Calif San Diego	USA	COCHANNEL INTERFERENCE; CDMA; RANDOM SIGNATURE SEQUENCES;	16
NAKAGAWA, M	Keio Univ	Japan	CDMA; TIME DIVISION DUPLEX; MULTIMEDIA NETWORK;	16
HIGUCHI, K	NTT DoCoMo Inc	Japan	DS-CDMA; MOBILE RADIO; W-CDMA;	15
ZORZI, M	Univ Ferrara	Italy	ALOHA; MARKOV CHANNEL; PACKET ACCESS;	15
CHO, DH	Korea Adv Inst Sci & Technol	South Korea	MULTIPLE-ACESS; PCS; HANDOVER;	14
TANAKA, S	NTT DoCoMo Inc	Japan	ADAPTIVE ANTENNA ARRAY; DS-CDMA; MOBILE RADIO;	12
UMEHIRA, M	NTT	Japan	WIRELESS ATM; ARQ; COHERENT DETECTION;	12
LEUNG, VCM	Univ British Columbia	Canada	WIRELESS ATM; PERSONAL COMMUNICATION; PATH OPTIMIZATION;	11
WU, G	Minist Posts & Telecommun	Japan	INTEGRATION OF VOICE AND DATA; MOBILE MULTIMEDIA; CHANNEL ACCESS PROTOCOL;	11
GERLA, M	Univ Calif Los	USA	MOBILE COMPUTING; AD HOC	10

	Angeles		NETWORKS; HIERARCHICAL ROUTING;	
GIANNETTI, F	European Space Agcy	Italy	CDMA; SYNCHRONIZATION; INTERFERENCE SUPPRESSION;	10
JEONG, DG	Hankuk Univ Foreign Studies	South Korea	CDMA/TDD; RESOURCE ALLOCATION; TRAFFIC ASYMMETRY;	10
KOBAYASHI, T	YRP Mobile Telecommun Key Technol Res Labs Co Ltd	Japan	CDMA; TRANSMISSION POWER CONTROL; MOBILE COMMUNICATION;	10
MORINAGA, N	Osaka Univ	Japan	QAM; ADAPTIVE MODULATION; DS/CDMA; MOBILE RADIO COMMUNICATIONS;	10
OKAWA, K	NTT DoCoMo Inc	Japan	MOBILE RADIO; W-CDMA; ITERATIVE CHANNEL ESTIMATION;	10
SOLLENBERGER, NR	AT&T Bell Labs	USA	INTERFERENCE SUPPRESSION; EQUALIZATION; TRANSMITTER DIVERSITY;	10
BAIER, PW	Univ Kaiserslautern	Germany	ADAPTIVE ANTENNAS; TD-CDMA DOWNLINK; CODE POOLING;	9

Of the twenty most prolific authors listed in Table 2, ten are from Japan. In fact, twelve are from Asia, four are from Europe (Western), and four are from North America. Ten are from universities, seven are from private industry, and three are from research institutes. These prolific author results show that private industry contained a substantial portion of the most prolific WLAN research and development authors in the 1991 to mid-2002 time frame, reflecting the more applied research nature of much of the reported work.

Not all the authors or papers are independent. For example, Adachi, Sawahashi, Higuchi, and Tanaka published, in various sub-groups, many papers together.

4.1.1.2. **Author Frequency Results Update**

Immediately prior to publication of this report, it was decided to include an updated version of selected bibliometrics results. For the author frequency results update, the query shown in the Introduction (plus the word MANET) was inserted in the SCI search engine, the time frame was set from 2004 to mid-2005, and 2293 records were retrieved. Using the newly-available Analyze function on the SCI screen, the most recent 2000 of these records were analyzed. The author frequency results for 2004-2005 are shown in Table 2-U.

TABLE 2-U – MOST PROLIFIC AUTHORS – 2004-MID-2005

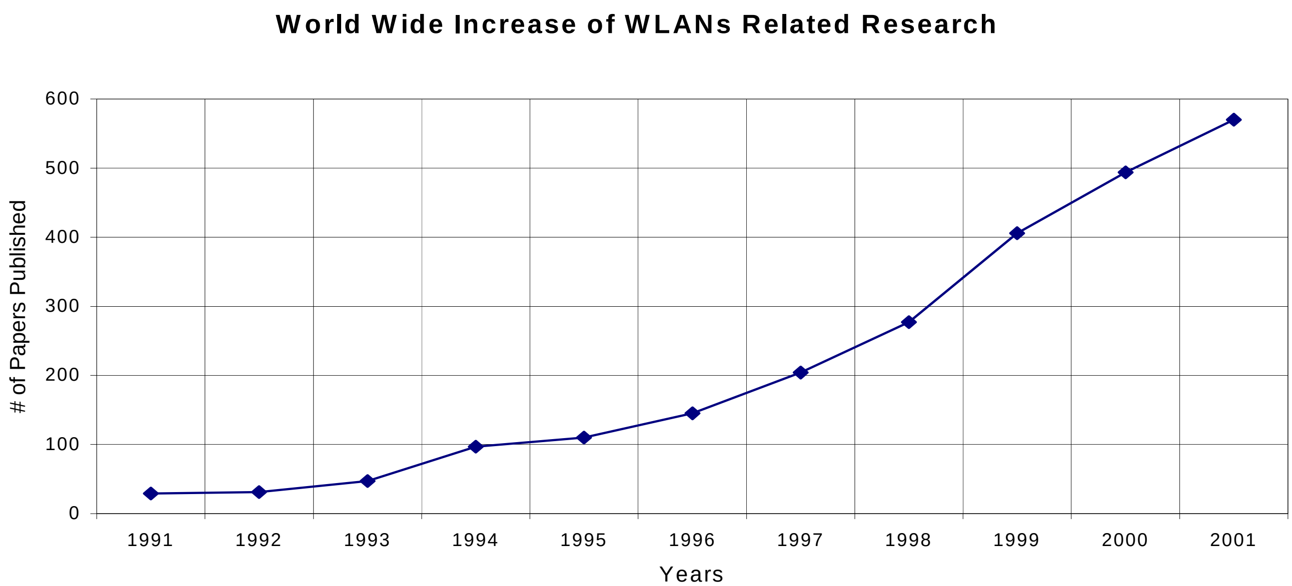
AUTHOR	#PAPERS
WONG, KL	21

WANG, Y	12
LEE, J	11
YOU, YH	11
FANG, YG	10
HAN, KJ	10
KIM, J	9
GARCIA-LUNA-ACEVES, JJ	8
KIM, Y	8
LU, SW	8
PARK, J	8
SONG, HK	8
STOJMENOVIC, I	8
TSENG, YC	8
ADACHI, F	7
KIM, D	7
LIN, YS	7
PAN, CY	7
WANG, L	7

All but two of the names are of Asian origin. The significance of this will be seen in the update of most prolific countries.

Figure 1 shows the number of WLAN papers published as a function of time. Since the mid-90s, there has been an approximate linear increase in papers published, at about the rate of 100 papers per year.

FIGURE 1 – PAPERS PUBLISHED IN THE SCI VS TIME



4.1.1.2 Author Clustering Results

Two statistical clustering processes are used to cluster authors: factor matrix and multi-link aggregation. A correlation matrix among the authors is generated as the basis for the factor matrix approach. A square co-occurrence matrix of the 240 most prolific authors (each matrix element represents the number of times each author pair is listed on the same paper) was generated as the basis for the multi-link aggregation.

4.1.1.2.1 Factor Matrix

First, a list of authors and their co-occurrences in the WLAN database was generated. The list and co-occurrences were used to create a correlation matrix, using the WINSTAT software package. WINSTAT then used the correlation matrix to create a factor matrix. Each matrix element contains the factor loading, a measure of the importance of each author to each factor. The number of factors was unconstrained, but the eigenvalues had a floor of unity. Practically, this means that each factor provides some additional useful information.

Appendix 4 contains the factor matrix for the 240 most prolific authors. Factor loading values above a threshold were shaded. Each column represents one factor, and the dark vertical bands in each column represent the essential contributors to each factor. The most cohesive factors start from the left column, and proceed to decrease in strength monotonically to the right. Thus, the strongest factor is the first, consisting of the authors ranging from Ju MC to Chow JW.

The factors are not fully orthogonal, so some authors can be connected strongly to more than one factor, and all the authors that represent the core of a factor are not necessarily presented in contiguous form.

4.1.1.2.2 Multi-Link Aggregation

Multi-link aggregation clustering of WLAN authors was performed to obtain more details on how strongly linked collaborating authors were, as well as to obtain a slightly different perspective on the groupings. The clusters of related authors were generated using the multi-link aggregation method of the WINSTAT software package described in Appendix 3.

Appendix 5 contains the full dendrogram for the 240 most prolific authors. The ordinate is the 'distance', a measure of the coupling strength between authors, or groups of authors. Smaller 'distance' means stronger coupling. The abcissa is authors, and positioning of an author, or group of authors, along the axis also reflects the relationships among authors or among groups.

The authors from Factor 1 of the factor matrix are shown to constitute a cluster (close to the bottom of the dendrogram). In this portrayal, however, the detailed structure within the Factor 1 cluster is evident from the dendrogram's tree-like structure. Ju, You, and Park form a tightly knit unit of collaborating authors; that unit combines with Paik to form a less tightly knit unit, and then combines in turn with Cho.

Table 2A is a co-occurrence matrix of the authors contained in Factor 1.

TABLE 2A - FACTOR 1 AUTHORS CO-OCCURRENCE MATRIX

# OF PAPERS	**AUTHOR NAMES**	**CHO--JW**	**JU--MC**	**PAIK--JH**	**PARK--CH**	**YOU--YH**
7	**CHO--JW**	7	6	5	5	6
7	**JU—MC**	6	7	6	6	7
6	**PAIK--JH**	5	6	6	5	6
6	**PARK--CH**	5	6	5	6	6

7	**YOU--YH**	6	7	6	6	7

The closeness of the authors depicted schematically on the dendrogram is confirmed by the actual numbers of papers. All of Ju's and You's papers are published with each other, and all but one was published with Park. Paik had six papers, all of which were published with Ju and You. Hence, Paik is the next closest group member in the dendrogram, followed by Cho who also published very closely with all the other authors.

4.1.2 Journals Containing Most Wireless LAN Papers

There were 285 different journals represented, with an average of 8.17 papers per journal. The journals containing the most Wireless LAN papers (see Table 3) had more than an order of magnitude more papers than the average.

TABLE 3 – JOURNALS CONTAINING MOST PAPERS – 1991-MID-2002

JOURNAL NAMES	# OF PAPERS
IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS	237
IEICE TRANSACTIONS ON COMMUNICATIONS	183
IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY	159
ELECTRONICS LETTERS	115
IEEE TRANSACTIONS ON COMMUNICATIONS	105
IEEE COMMUNICATIONS MAGAZINE	94
IEICE TRANSACTIONS ON FUNDAMENTALS OF ELECTRONICS COMMUNICATIONS AND COMPUTER SCIENCES	73
MICROWAVES & RF	71
IEEE PERSONAL COMMUNICATIONS	61
WIRELESS NETWORKS	60
COMPUTER COMMUNICATIONS	59
MOBILE NETWORKS & APPLICATIONS	41
COMPUTER NETWORKS-THE INTERNATIONAL JOURNAL OF COMPUTER AND TELECOMMUNICATIONS NETWORKING	39
IEE PROCEEDINGS-COMMUNICATIONS	33
IEEE TRANSACTIONS ON CONSUMER ELECTRONICS	31
ELECTRONICS AND COMMUNICATIONS IN JAPAN PART I-COMMUNICATIONS	28
WIRELESS PERSONAL COMMUNICATIONS	28
IEEE COMMUNICATIONS LETTERS	27
IEEE NETWORK	26
IEEE JOURNAL OF SOLID-STATE CIRCUITS	26

The majority of the journals are focused on communications, with the remainder divided between networking and electronics. Bradford's Law allows journals to be divided into groups, with each group containing roughly similar numbers of publications, and the number of journals in each group differing by a constant. There appear to be two primary groups at the top layer. The *IEEE Journal on Selected Areas in Communications* contains the most articles by far and, along with the Journal of the *IEICE Transactions on Communications* and *IEEE Transactions on Vehicular Technology*, constitutes the first group. The next group consists of *Electronics Letters, IEEE Transactions on Communications, IEEE Communications Magazine, IEICE Transactions on Fundamentals of Electronics Communications and Computer Sciences*, *Microwaves & RF, IEEE Personal Communications,* and *Wireless Networks*.

While *IEEE Transactions on Vehicular Technology* may seem out of place, this journal publishes many papers dealing with electrical and electronics technology in vehicles and vehicular systems. The areas of communications, transportation systems, and vehicular electronics define its scope.

4.1.2.1. Journals Containing Most Wireless LAN Papers Update

The 2004-mid-2005 papers were retrieved from the SCI, and the journals containing the most Wireless LANs papers were identified. The results are shown on Table 3-U.

TABLE 3-U – JOURNALS CONTAINING MOST PAPERS – 2004-MID-2005

JOURNAL	#PAPERS
IEICE TRANSACTIONS ON COMMUNICATIONS	121
IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS	83
COMPUTER COMMUNICATIONS	59
WIRELESS COMMUNICATIONS & MOBILE COMPUTING	53
IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS	50
MICROWAVE AND OPTICAL TECHNOLOGY LETTERS	47
IEEE TRANSACTIONS ON MOBILE COMPUTING	44
ELECTRONICS LETTERS	37
IEEE TRANSACTIONS ON CONSUMER ELECTRONICS	37
IEEE WIRELESS COMMUNICATIONS	37
NETWORKING - ICN 2005, PT 2	37
IEEE COMMUNICATIONS LETTERS	35
IEEE JOURNAL OF SOLID-STATE CIRCUITS	35
WIRELESS NETWORKS	35

IEEE COMMUNICATIONS MAGAZINE	32
COMPUTER NETWORKS-	31
NETWORKING 2004	30
MOBILE NETWORKS & APPLICATIONS	29
TELECOMMUNICATIONS AND NETWORKING - ICT 2004	29

Of the 21 journals pre-2003, and the 19 journals post-2003 listed, ten were in common. Of those not shared, many of the recent papers appear in journals whose titles suggest a wireless focus and a mobile networking focus. Because of the technology specificity, these more recent papers have even more of an application focus of what was perceived as an already quite applied discipline.

4.1.3 Institutions Producing Most Wireless LAN Papers

A similar process was used to develop a frequency count of institutional address appearances. It should be noted that many different organizational components may be included under the single organizational heading (e.g., Univ Calif Los Angeles could include the Department of Computer Science, Department of Electrical Engineering, etc.). Identifying the higher level institutions is instrumental for these DT studies. Once they have been identified through bibliometric analysis, subsequent measures may be taken (if desired) to identify particular departments within an institution.

TABLE 4 – PROLIFIC INSTITUTIONS – 1991-MID-2002

INSTITUTION	COUNTRY	# OF PAPERS
NTT	JAPAN	136
AT&T BELL LABS	USA	93
UNIV CALIF LOS ANGELES	USA	41
UNIV CALIF SAN DIEGO	USA	35
NEC CORP	USA	35
NATL CHIAO TUNG UNIV	TAIWAN	33
KOREA ADV INST SCI & TECHNOL	SOUTH KOREA	29
NATL UNIV SINGAPORE	SINGAPORE	27
KEIO UNIV	JAPAN	27
STANFORD UNIV	USA	25
UNIV CALIF BERKELEY	USA	25
GEORGIA INST TECHNOL	USA	25
UNIV TEXAS	USA	24
RUTGERS STATE UNIV	USA	24
IBM	USA	23
LUCENT TECHNOL	USA	22

SIEMENS AG	GERMANY	22
MOTOROLA INC	USA	21
ETRI	SOUTH KOREA	20
SEOUL NATL UNIV	SOUTH KOREA	20

Of the twenty most prolific institutions, ten are from Asia, five are from Western Europe, four from the USA, and one from Eastern Europe. Ten are universities, eight are privately owned businesses and the remaining institutions are research institutes. These distributions reflect those of the most prolific authors, and confirm the substantial contribution of the private sector.

4.1.3.1. Institutions Producing Most Wireless LAN Papers Update

The 2004-mid-2005 papers were retrieved from the SCI, and the institutions producing the most Wireless LANs papers were identified. The results are shown on Table 4-U.

TABLE 4-U – INSTITUTIONS PRODUCING MOST PAPERS – 2004-MID-2005

INSTITUTION	#PAPERS
NATL SUN YAT SEN UNIV	36
KOREA UNIV	33
GEORGIA INST TECHNOL	30
NATL CHIAO TUNG UNIV	28
UNIV ILLINOIS	27
TSING HUA UNIV	26
NANYANG TECHNOL UNIV	25
KYUNGPOOK NATL UNIV	21
UNIV TEXAS	21
UNIV OTTAWA	20
UNIV CALIF LOS ANGELES	19
UNIV FLORIDA	19
NATL TAIWAN UNIV	18
SEJONG UNIV	18
ARIZONA STATE UNIV	17
INDIAN INST TECHNOL	17
UNIV WATERLOO	17
HONG KONG UNIV SCI & TECHNOL	16
UNIV MARYLAND	16
YONSEI UNIV	16

There has been a shift in the most prolific institutions from mainly USA to Asian. Also, none of the industrial organizations (that were so prominent in Table 4) appear in the latest results. This absence of industry can be seen more dramatically by displaying the results from the period 1991-1995 only. Table 4-U-U presents these results for the top 26 institutions. Over 25% are industrial organizations.

TABLE 4-U-U – INSTITUTIONS PRODUCING MOST PAPERS – 1991-1995

INSTITUTION	#PAPERS
KERNFORSCHUNGSZENTRUM KARLSRUHE GMBH	21
NIPPON TELEGRAPH & TEL PUBL CORP	16
AT&T BELL LABS	11
COMMISS EUROPEAN COMMUNITIES	11
NATL UNIV SINGAPORE	10
UNIV ANCONA	9
UNIV CALIF SAN DIEGO	7
UNIV KAISERSLAUTERN	7
BELLCORE	6
CARLETON UNIV	6
DELFT UNIV TECHNOL	6
IBM CORP	6
UNIV ROMA TOR VERGATA	6
ENEA CASACCIA	5
KOREA ADV INST SCI & TECHNOL	5
UNIV CALIF DAVIS	5
KFA JULICH GMBH	4
MOTOROLA INC	4
POLITECN TURIN	4
RUSSIAN ACAD SCI	4
SIEMENS AG	4
UNIV ARIZONA	4
UNIV CALIF BERKELEY	4
UNIV VICTORIA	4
USN	4
ENEA	3

4.1.4 Countries Producing Most Wireless LAN Papers

There are 51 different countries listed in the results. The country bibliometric results are summarized in Table 5. The dominance of a handful of countries is clearly evident.

TABLE 5 – PROLIFIC COUNTRIES – 1991-MID-2002

COUNTRY	# OF

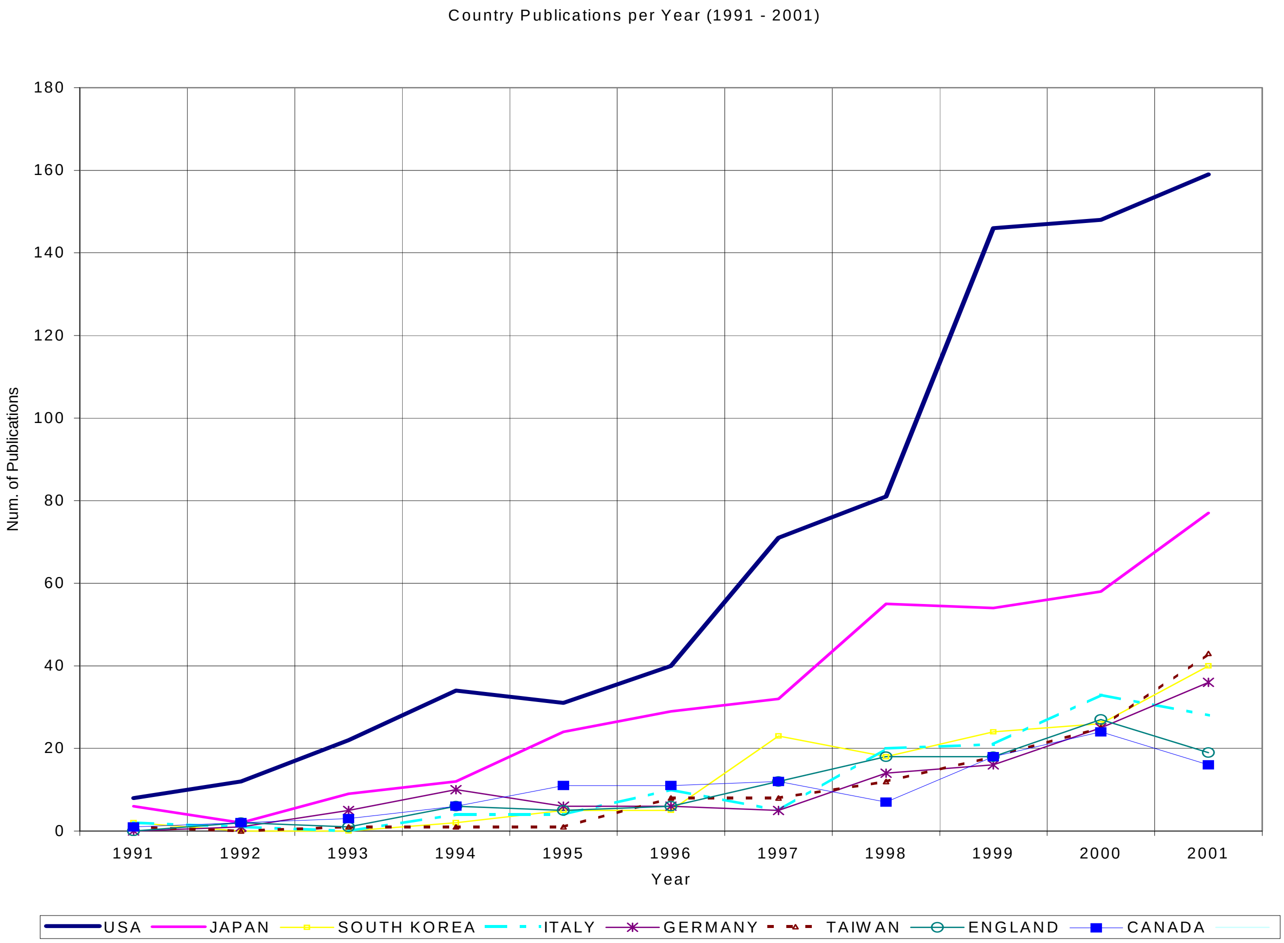
	PAPERS
USA	754
JAPAN	361
SOUTH KOREA	146
ITALY	129
GERMANY	124
TAIWAN	118
ENGLAND	114
CANADA	112
SINGAPORE	59
AUSTRALIA	50
PEOPLES R CHINA	49
NETHERLANDS	48
GREECE	42
FRANCE	37
FINLAND	36
SWEDEN	28
SPAIN	27
INDIA	23
HONG KONG	18
SWITZERLAND	18

There appear to be three dominant groups in the twenty most prolific countries. The USA is in a group of its own, with more than twice the number of papers as the next most prolific country. Japan constitutes the second most dominant group with substantially more papers than the third most prolific country. The sum of papers from the USA and Japan almost surpasses the cumulative sum of the next eighteen most prolific countries. South Korea, Italy, Germany, Taiwan, England and Canada make up the third most prolific group. Of the eleven most prolific countries, five are Asian, confirming the prolific author and institution results. With the exception of perhaps China, the developing nations are playing almost no role in the literature contribution of Wireless LANs.

4.1.4.1 Country Publications With Respect To Time

There has been a dramatic increase in the number of publications that different countries have produced, dealing with Wireless LANs. As Figure 2 illustrates, the most notable increase has been within the United States. Japan, having less of an increase than the United States, still has had an increase in publications that well surpasses any of the other countries.

FIGURE 2 – COUNTRY PUBLICATIONS VS TIME



Appendix 6 contains a co-occurrence matrix of the top 15 countries. In terms of absolute numbers of co-authored papers, the USA major partners are Italy, Japan, Canada, and South Korea. Of the top 15 countries publishing Wireless LAN papers, most did not have a substantial amount of inter-country published papers. In cases where there was inter-country publishing, it typically was with countries in similar geographical regions. The USA was perhaps the exception – co-publishing with many other countries from various geographical regions.

4.1.4.2. Countries Producing Most Wireless LAN Papers Update

The 2004-mid-2005 papers were retrieved from the SCI, and the countries producing the most Wireless LANs papers were identified. The results are shown on Table 5-U.

TABLE 5-U – COUNTRIES PRODUCING MOST PAPERS – 2004-MID-2005

COUNTRY	#PAPERS
USA	572
SOUTH KOREA	246
JAPAN	166
TAIWAN	165
PEOPLES R CHINA	140
CANADA	121
GERMANY	96
ITALY	92
FRANCE	83
GREECE	66
ENGLAND	57
SPAIN	52
INDIA	50
SINGAPORE	49
SWITZERLAND	35
NETHERLANDS	31
FINLAND	29
AUSTRALIA	26
SWEDEN	20
TURKEY	19
BELGIUM	17
BRAZIL	16

For dramatic comparison, the countries producing the most papers from 1991-1995 were tabulated. The results are shown in Table 5-U-U.

TABLE 5-U-U – COUNTRIES PRODUCING MOST PAPERS – 1991-1995

COUNTRY	#PAPERS
USA	103
GERMANY	50
JAPAN	45
ITALY	38
CANADA	25
ENGLAND	14
NETHERLANDS	12
SINGAPORE	10
FRANCE	9
SOUTH KOREA	7
AUSTRALIA	6
GREECE	4
RUSSIA	4
SWITZERLAND	4
INDIA	3

SWEDEN	3
TAIWAN	3
ARGENTINA	2
BYELARUS	2
HONG KONG	2
ISRAEL	2
NEW ZEALAND	2
PORTUGAL	2
SCOTLAND	2
SPAIN	2

There has been a major shift in country emphasis in the past decade. Except for the USA, the Western nations' leadership has been replaced by that of the Asian nations. Especially large advances have been made by South Korea (7% of USA paper production a decade ago to 43% of USA production presently), Taiwan (3% of USA to 29% of USA), and Peoples Republic of China (1% of USA to 25% of USA).

4.1.5 Citation Statistics on Authors, Papers, and Journals

The second group of metrics presented is counts of citations to papers published by different entities. While citations are ordinarily used as impact or quality metrics [Garfield, 1985], much caution needs to be exercised in their frequency count interpretation, since there are numerous reasons why authors cite or do not cite particular papers [Kostoff, 1988b; MacRoberts, 1996].

The citations in all the retrieved SCI papers (from 1991 to mid-2002) were aggregated. The authors, specific papers, years, journals, and countries cited most frequently were identified, and were presented in order of decreasing frequency. A small percentage of any of these categories received large numbers of citations. From the citation year results, the most recent papers tended to be the most highly cited. This reflected rapidly evolving fields of research.

4.1.5.1 Most Cited First Authors

The most highly cited first authors are listed in Table 6.

TABLE 6 – MOST CITED FIRST AUTHORS
(cited by other papers in this database only)

AUTHOR	INSTITUTION	COUNTRY	TIMES CITED
VITERBI AJ	Qualcomm Inc	USA	276
RAYCHAUDHURI D	Rutgers State Univ	USA	267

PROAKIS JG	Northeastern Univ	USA	235
PERKINS C	Nokia Res Ctr	USA	233
GILHOUSEN KS	Qualcomm Inc	USA	226
LEE WCY	LinkAir Commun Inc	USA	191
GOODMAN DJ	Polytech Univ	USA	189
KLEINROCK L	Univ Calif Los Angeles	USA	150
ADACHI F	Tohoku Univ	Japan	146
PURSLEY MB	Clemson Univ	USA	140
TOBAGI FA	Stanford Univ	USA	137
ZORZI M	Univ Ferrara	Italy	136
RAPPAPORT TS	Virginia Polytech Inst & State Univ	USA	134
JAKES WC	Bell Tel Labs Inc	USA	130
VERDU S	Princeton Univ	USA	118
PAHLAVAN K	Worcester Polytech Inst	USA	111
KOHNO R	Futaba Corp	Japan	103
TOH CK	Georgia Inst Technol	USA	99
ACAMPORA AS	Univ Calif San Diego	USA	94
JOHNSON DB	Carnegie Mellon Univ	USA	94

Of the twenty most cited authors, seventeen are from North America (USA), two are from Asia (Japan), and one is from Europe (Italy). This is a far different distribution from the most prolific authors, where twelve were from Asia (Far East). There are a number of potential reasons for this difference, including difference in quality and late entry into the Wireless LANs research discipline. In another three or four years, when the papers from present-day authors have accumulated sufficient citations, firmer conclusions about quality can be drawn.

The lists of twenty most prolific authors and twenty most highly cited first authors had only two names in common (ADACHI, ZORZI). This phenomenon of minimal intersection has been observed in all other text mining studies performed by the first author of the present report. The time frame of interest for most prolific authors is present time, whereas the time frame of interest for most cited can span many decades. Researchers who may very well have been prolific when their most citable work was done may no longer be prolific. Finally, many prolific authors, especially at academic institutions, tend not to be first authors in most of their publications. Therefore, they tend to be severely under-represented in the SCI citation downloads, which contain first author only.

Twelve of the top twenty cited authors' institutions are universities, and five are private companies. This differs somewhat from the most prolific authors in that the distribution between universities and privately owned businesses is ten to seven respectively.

The citation data for authors and journals represents citations generated only by the specific records extracted from the SCI database for this Wireless LANs study. It does not represent all the citations received by the references in those records; these references (in the database records) could have been cited additionally by papers in other technical disciplines.

4.1.5.2 Most Cited Papers

The most highly cited papers are listed in Table 7.

TABLE 7 – MOST CITED PAPERS
(total citations from retrieved papers)

PUBLICATIONS (PAPER / BOOKS)	TIMES CITED
GILHOUSEN KS, 1991, IEEE T VEH TECHNOL, V40, P303 (*Interference suppression features of CDMA, and the resulting increase in capacity over competing multiple access techniques*)	179
PROAKIS JG, 1989, DIGITAL COMMUNICATIO (*Basic principles that underlie the analysis and design of digital communication systems*)	93
VITERBI AJ, 1995, CDMA PRINCIPLES SPRE (*CDMA and the commercial implementation of spread spectrum technology that underpins the surge in personal wireless communication*)	89
JAKES WC, 1974, MICROWAVE MOBILE COM (*Basic microwave theory, overview of cellular systems, and useful techniques for effective mobile microwave systems development*)	85
PROAKIS JG, 1995, DIGITAL COMMUNICATIO (*Basic principles that underlie the analysis and design of digital communication systems*)	83
RAYCHAUDHURI D, 1994, IEEE J SEL AREA COMM, V12, P1401 (*ATM-Based transport architecture for multi-services wireless personal communication-networks*)	79
GOODMAN DJ, 1989, IEEE T COMMUN, V37, P885 (*Packet reservation multiple access for local wireless communications*)	73
LEE WCY, 1991, IEEE T VEH TECHNOL, V40, P291 (*Overview of cellular CDMA*)	68
PURSLEY MB, 1977, IEEE T COMMUN, V25, P795	67

(*Evaluation for phase-coded spread-spectrum multiple-access communication*)	
BAIER A, 1994, IEEE J SEL AREA COMM, V12, P733 (*CDMA-Based 3rd-generation mobile radio system*)	51
RAPPAPORT TS, 1996, WIRELESS COMMUNICATI (*Wireless communications technology and system design. Covers the basic issues affecting all wireless networks and reviews new technological developments, with particular attention to SG systems and wireless LANs*)	49
ACAMPORA AS, 1994, IEEE J SEL AREA COMM, V12, P1365 (*Architecture and methodology for mobile-executed handoff in cellular ATM networks*)	49
VITERBI AM, 1993, IEEE J SEL AREA COMM, V11, P892 (*Erlang capacity of a power controlled CDMA system*)	46
PICKHOLTZ RL, 1991, IEEE T VEH TECHNOL, V40, P313 (*Spread spectrum for mobile communications*)	43
RAYCHAUDHURI D, 1997, IEEE J SEL AREA COMM, V15, P83 (*Prototype wireless ATM system for multimedia personal communication*)	41
BERTSEKAS D, 1992, DATA NETWORKS (*An exploration of data networks, evolving integrated networks, and the various analysis and design tools*)	40
KLEINROCK L, 1975, IEEE T COMMUN, V23, P1400 (*Packet switching in radio channels. CSMA modes and their throughput-delay characteristics*)	39
ADACHI F, 1998, IEEE COMMUN MAG, V36, P56 (*Wideband DS-CDMA for next-generation mobile communications systems*)	39
LIN S, 1983, ERROR CONTROL CODING (*The fundamentals of coding and the applications of codes to the design of real error control systems*)	38
NANDA S, 1991, IEEE T VEH TECHNOL, V40, P584 (*Performance of PRMA - a packet voice protocol for cellular-systems*)	38

The theme of each paper is shown in italics on the line after the paper listing. The order of paper listings is by number of citations by the Wireless LAN papers in the extracted database.

The focal points of the majority of the papers shown here are CDMA (Code-Division Multiple Access) and other protocols within Wireless LANs. There are a number of other topics addressed within the papers as well, including data transmission and throughput in ATM (Asynchronous Transfer Mode) networks and

Spread Spectrum technology, Network Architecture, and a broader group that focuses on different applications for Wireless Networks.

A more comprehensive listing of highly cited documents is contained in Appendix 13. In this Appendix, the first author's Citation-Assisted Background (CAB) method [Kostoff and Shlesinger, 2005d] is used to identify the seminal documents in Wireless LANs, and present these seminal documents in chronological order.

4.1.5.3. Most Cited Journals

TABLE 8 – MOST CITED JOURNALS
(cited by other papers in this database only)

JOURNAL	TIMES CITED
IEEE T COMMUN	2804
IEEE J SEL AREA COMM	2178
IEEE T VEH TECHNOL	1545
IEEE COMMUN MAG	691
IEEE T INFORM THEORY	500
IEEE PERS COMMUN	499
P IEEE	490
IEICE T COMMUN	380
ELECTRON LETT	352
DIGITAL COMMUNICATIO	310
IEEE J SOLID-ST CIRC	224
IEEE T SIGNAL PROCES	206
BELL SYST TECH J	194
IEEE ACM T NETWORK	188
IEEE T ANTENN PROPAG	168
WIREL NETW	164
MICROWAVE MOBILE COM	134
IEEE T COMPUT	124
COMPUT NETWORKS ISDN	123
IEEE NETWORK	108

The list of most cited journals is very similar to the list of most prolific journals, although some items are not in the same order.

Based on the bibliometric results, it is recommended that those who are interested in researching wireless LANs would be well-advised to, first, obtain the highly-cited papers listed and, second, peruse those sources that are highly cited and/or contain large numbers of recently published papers.

4.2 Database Tomography Results

There are two major analytic methods used in this section to generate taxonomies of the SCI databases: concept clustering, based on phrase/ word aggregation, and document clustering, based on document aggregation. Counting of documents within each major cluster/ category provides some estimate of level of effort within the thematic area represented by the cluster.

4.2.1 Taxonomies

Two statistically based concept clustering methods were used to develop taxonomies: factor matrix clustering and multi-link clustering. Both offer different perspectives on taxonomy category structure from the document clustering approach described later.

In this section, a synergistic combination of factor matrix and multi-link clustering is described that offers substantial improvement in the quality of the resultant clusters. Once the appropriate factor matrix has been generated, the factor matrix can then be used as a filter to identify the significant technical words/ phrases for further analysis. Specifically, the factor matrix can complement a basic trivial word list (i.e., a list containing words that are trivial in almost all contexts, such as 'a', 'the', 'of', 'and', 'or', etc) to select context-dependent high technical content words/ phrases for input to a clustering algorithm. The factor matrix pre-filtering will improve the cohesiveness of clustering by eliminating those words/ phrases that are trivial words operationally in the application context [Kostoff, 2003d; Kostoff et al, 2005c].

4.2.1.1 Statistical Clustering

Appendix 3 describes the statistical clustering methodologies in more detail. Appendix 3A overviews the generic statistically-based clustering approach, Appendix 3B describes the factor matrix clustering, and Appendix 3C describes the multi-link clustering.

4.2.1.1.1 Concept Clustering

4.2.1.1.1.1 Word and Multiple-Phrase Factor Matrices

Correlation matrices of the 735 highest frequency high technical content words and 704 highest frequency high technical content multiple-word phrases were generated, and factor analyses were performed using the Tech Oasis statistical package. Based on Scree Plot analysis to estimate the number of factors required, factor matrices consisting of 12 factors resulted. A description of these factors, and their aggregation into taxonomies, follows. The words/ phrases in parentheses represent typical high factor loading words/ phrases for that factor. The complete word factor matrix is presented in Appendix 7, and the complete phrase factor matrix is presented in Appendix 8. In both these appendices, the rows contain the words or phrases extracted from the free text Abstracts, and the columns contain the factors. Each factor represents a technical theme of the database, with the first factor being the most coherent, and the coherency decreasing monotonically to the last factor.

In the multi-link section following the factor matrices, taxonomies will be generated using the multi-link hierarchical clustering approach. The twelve factors for words and phrases will then be assigned to the appropriate categories in the taxonomy, providing good coverage and an excellent match.

4.2.1.1.1.1.1 Word Factor Matrix

Factor 1 (ARQ, error, automatic, Correction, retransmission, request, bit, data, link, rate, transport, throughput, errors, TCP, forward, layer) – focuses on the use of the ARQ (Automatic Repeat Request) scheme to compile erroneous and fragmented packets. Multiple copies of the packets are repeatedly transmitted until the error is corrected.

Factor 2 (MAC, collision, access, protocol, traffic, contention, medium, reservation, packet, throughput, priority, slots) – focuses on a number of different MAC (Medium Access Control) protocols, whose function is to prevent multi-station signals from colliding on identical channels.

Factor 3 (multimedia, IP, technology, broadband, research, technical, issues, future, telecommunications, service, Technologies, Internet, services) – focuses on broadband multimedia transmission that can carry numerous channels at once, allowing rapid data transfer.

Factor 4 (equalizer, equalization, multipath, interference, blind, multi-user, Response, feedback, inter-symbol, estimation, receiver, adaptive, impulse) –

focuses on the use of DFE (Decision Feedback Equalization) to combat multipath ISI (inter-symbol interference), prevalent within indoor wireless data networks.

Factor 5 (hosts, routing, network, multicast, hoc, ad, nodes, protocols, distributed, ATM, implementation) - focuses on mitigating the problem faced when mobile hosts attempt to communicate with one another on an ad-hoc network.

Factor 6 (CMOS, supply, GHz, V, circuit, amplifier, chip, power, RF, MHz, transceiver, dB, band) – focuses on CMOS (complimentary metal oxide semiconductors). GHz-range radio frequency and baseband circuits rely heavily on CMOS technology.

Factor 7 (ATM, Call, QoS, handoff, admission, blocking, service, transfer, calls, traffic, quality, connections) – focuses on ATM (Asynchronous Transfer Mode), a network technology based on transferring data in cells. These types of networks can guarantee a constant level of QoS (Quality-of-service) at all times.

Factor 8 (Rake, coherent, pilot, background, W-CDMA, reverse, laboratory, SIR, DS-CDMA, transmit, diversity, ratio, antenna, signal-to-interference, combining) – focuses on W-CDMA, which employs a fast cell-search algorithm and rake composition receivers to combat multipath interference.

Factor 9 (ad, hoc, routing, nodes, route, topology, mobility, hosts) – focuses on an adaptive network routing approach to assist in the communication of multiple mobile hosts within an ad-hoc network.

Factor 10 (probability, model, distribution, probabilities, derived, parameters, derive, models, analyze, analytical, expressions, approximation, outage) – focuses on the statistical analysis and modeling of MAC wireless protocols and their ability to prevent same-station channels from colliding.

Factor 11 (CDMA, code, division, capacity, mobile, multiple, code-division, cellular, multiple-access, base) – focuses on different types of CDMA (Code-Division Multiple Access) cellular-mobile and wireless communications.

Factor 12 (keying, modulation, shift, differential, orthogonal, phase, frequency, QPSK, fading, quadrature, codes, error, offset, symbol) – focuses on D-DQPSK (Double Differential Quadrature Phase Shift Keying) being applied to OFDM (Orthogonal Frequency Division Multiplexing), to cut down on the disturbance of signal transmissions by splitting the signal into smaller sub-signals.

4.3.1.1.1.1.2 Multiple-Word Phrase Factor Matrix

Factor 1 (MC-CDMA system, frequency diversity, OFDM, MC-CDMA, multipath fading channels, MAI, frequency selectivity, users, receiver, fading channels, ISI, spreading codes, intersymbol interference ISI) - focuses on Multi-Carrier CDMA (MC-CDMA) systems using the Orthogonal Frequency Division Multiple Access (OFDM) to resolve the frequency selectivity in multipath fading channels.

Factor 2 (Uplink channels, talkspurt, integrated voice, voice packets, medium access control protocol, voice terminals, time slots, data packets, collision, spreading codes, data services) - focuses on a MAC protocol for integrated voice and data services in which the uplink channels are composed of time slots with multiple spreading codes for each slot.

Factor 3 (power control TPC, fast TPC, average BER, fast, antenna diversity reception, link capacity, Rake combining, coherent Rake combining, pilot symbols, E-b/N-0) - focuses on BER (Bit Error Rate) in a channel without a fast TPC (Transmit Power Control), such as a common control channel in a real multipath-fading channel.

Factor 4 (voice communications, dispersed voice, data communications, data transmissions, random access protocol, data terminals, voice, voice packet, data traffic, voice terminals, PRMA, voice traffic, access) - focuses on a TDMA–based wireless network that provides access to a base station for many spatially dispersed voice and data terminals in an attempt to integrate voice and data communications.

Factor 5 (TDMA scheme, CDMA scheme, same frequency band, impulse response, mobile terminal, bit error rate performance, downlink, DFE, uplink, received signals, bit error rates) - focuses on a TDMA/CDMA network that connects mobile terminals to a LAN through a radio central unit and provides both uplink and downlink unbalanced data rates in the same frequency band.

Factor 6 (bandwidth allocation, QoS support, real-time applications, mobile environment, QoS, wired networks, simulation experiments, admission control, new calls, handoff calls, source, call admission control, on-demand) - focuses on a wireless ad-hoc network that is able to ensure QoS (Quality of Service) support at all times within a mobile environment through the use of bandwidth allocation.

Factor 7 (ad hoc networks, nodes, node, mobile nodes, multicast tree, ad hoc network, on-demand, topology, protocols, network, mobile hosts, multicast) - focuses on AD-HOC networks that are made up of a number of mobile hosts without a centralized system, and on the WMTP (Wireless Multicast Tree Problem) that occurs when two mobile nodes attempt to communicate with one another.

Factor 8 (station, throughput, channel, stations, wireless channel, ALOHA, Rayleigh fading, hidden terminals, backoff algorithm, capture, packet length, IEEE 802.11 protocol, capture effect, performance measures, protocol) - focuses on improving throughput and message delay delivery in a conventional slotted ALOHA protocol with the use of receiver capture. This also lessens path loss and channel fading.

Factor 9 (TCP, energy efficiency, wireless links, wireless link, transport, ARQ, packet size, low power, Service QoS requirements, energy, throughput, UDP) - focuses on improving TCP's (Transmission Control Protocol) energy efficiency in transporting data over wireless links. An ARQ (Automatic Repeat Request) mechanism will support TCP traffic over wireless networks.

Factor 10 (mobility support, wireless ATM, mobile ATM, location management, mobility, prototype implementation, handoff, mobile users, multimedia, PCS, ATM, voice services) - focuses on improving the mobility of ATM networks through the use of handoff and location management schemes.

Factor 11 (power control TPC, voice communications, data communications, dispersed voice, fast TPC, data transmissions, antenna diversity reception, average BER, coherent Rake combining, link capacity, Rake combining, fast) - focuses on the use of fast TPC (Transmit Power Control) and coherent Rake combining within a W-CDMA (Wideband Carrier Sense Multiple Acces) protocol to increase radio link capacity in Data and Voice based communications.

Factor 12 (handoff calls, new calls, cells, cell, base stations, neighboring cells, shadowing, reverse link, users, base station, system capacity) - focuses on a handoff management scheme for wireless ATM networks in which all cells are connected to neighboring cells by (PVC) permanent virtual circuits. Using PVC for handoff calls guarantees fast and seamless handoffs without necessarily relying on a base station.

This completes the specification of the word and phrase factor matrices.

Now that the twelve factor matrices have been generated, they can be used for word/ phrase filtering and selection for myriad applications. The desired application at this point is filtering words/ phrases for input to word/ phrase limited multi-link clustering algorithms. In the present study, the 735 words and 704 phrases in the factor matrices have to be culled to the approximately 250 allowed by the Excel-based clustering package, WINSTAT. The 250 word limit is an artifact of Excel. Other software packages may allow more or less words to be used for clustering, but all approaches perform culling to reduce dimensionality. The filtering process presented here is applicable to any level of filtered words desired.

The factor loadings in the factor matrix were converted to absolute values. Then, a simple algorithm was used to automatically extract those high factor loading words at the tail of each factor. If word variants were on this list (e.g., singles and plurals), and their factor loadings were reasonably close (Kostoff, 2003b), they were conflated (e.g., 'agent' and 'agents' were conflated into 'agents', and their frequencies were added). A few words were eliminated manually, based on factor loading and estimate of technical content.

4.2.1.1.1.2 Word and Phrase Multi-Link Clustering

A symmetrical co-occurrence matrix of the 253 highest frequency high technical content words was generated. The matrix elements were normalized using the Equivalence Index (Eij=Cij^2/Ci*Cj, where Ci is the total occurrence frequency of the ith phrase, and Cj is the total occurrence frequency of the jth phrase, for the matrix element ij), and a multi-link clustering analysis was performed using the WINSTAT statistical package. The Average Linkage hierarchical aggregation method was used. A description of the final 253 word and phrase dendrograms (a hierarchical tree-like structure), and the aggregation of their branches into a taxonomy of categories, follows. Appendix 9 is the dendrogram of the 253 words and Appendix 10 is the dendrogram of the 253 phrases. One axis is the words, and the other axis ('distance') reflects their similarity. The lower the value of 'distance' at which words, or word groups, are linked together, the closer their relation. As an extreme case of illustration, words that tend to appear as members of multi-word phrases, such as 'Inter-Symbol Interference', 'Medium Access Control', or 'multicast tree', appear adjacent on the dendrogram with very low values of 'distance' at their juncture. The capitalized phrases in parentheses represent cluster boundary phrases for each category.

Experience with both word and phrase clustering from past text mining studies has shown the following. Word clustering is most useful in determining the scope and thematic thrusts of the higher hierarchical categories, because of the greater breadth of single words. Phrase clustering is most useful in determining the thematic thrusts of individual lower hierarchical level clusters, because of the more specific nature of phrases. Therefore, only the single words will be used to determine the themes of the higher and broader categorical levels, but both word and phrase clustering will be used to determine the themes of the lower and more focused categorical levels.

4.3.1.1.2.1 Word Multi-Link Clustering

The 253 words in the dendrogram are grouped into 21 elemental clusters. These clusters form the lowest level of the taxonomy hierarchy. Each cluster is assigned a letter, ranging from A to U. The cluster hierarchies are determined by the branch structure of the dendrogram. At the highest hierarchical level, there are two main branches (clusters). Starting from the phrase adjoining the ‘distance’ ordinate, the first main cluster (A-E) ranges from WIRELESS to RECEIVED. The second main cluster (F-U) ranges from COMMUNICATIONS to 2.4, and is moderately larger in extent than the first main cluster. The total dendrogram reflects different aspects of increasing Wireless LANs’ throughput. The first cluster (A-E) addresses protocols (CDMA) to control channel packet traffic and increase throughput and user capacity, as well as efforts at the physical layer to reduce interference limitations on throughput of WLANs. The second cluster (F-U) covers Network Architecture and Applications designed to improve throughput and reduce latency effects from multi-path signal propagation, including Infrastructure, protocols, hardware and applications. Each of these highest level clusters will be divided and sub-divided into smaller clusters, and discussed.

Cluster (A-E) can be divided into clusters (A-B) and (C-E). Cluster (A-B) ranges from WIRELESS to ANALYTICAL, and cluster (C-E) ranges from POWER to RECEIVED. Cluster (A-B) focuses on the simulation of data transmissions, especially using CDMA and other packet traffic schemes affecting throughput, delay, and user accessibility. Cluster (C-E) focuses on interference issues of the physical layer and on ways of mitigating them (Rake combining and antennas/ receivers).

Cluster (F-U) can be divided into clusters (F-P) and (Q-U), where cluster (F-P) is much larger than cluster (Q-U). Cluster (F-P) ranges from COMMUNICATIONS to DETECTOR, and cluster (Q-U) ranges from JOINT to 2.4. Cluster (F-P) focuses on network hardware and architectures and methods for increasing throughput (such as ATM for dynamic bandwidth allocation, or MAC and other transport protocols). In addition, some applications of the encompassed technologies are included. Cluster (Q-U) focuses on signal propagation, and especially the use of QPSK and OFDM within CDMA to make the system more robust to effects such as multipath-induced intersymbol interference.

(The following is a listing of the lowest level word clusters, with a brief summarization of each cluster following the range)

Cluster A (Wireless to Radio) focuses on the transmission of data within a standard wireless network and on several different protocols that format this data.

Cluster B (Access to Analytical) focuses on CDMA (code-division multiple access) slotted ALOHA schemes aimed at improving throughput and message delay delivery when traffic loads are sensed within a channel.

Cluster C (Power to Multipath) focuses on the use of power control to improve the BER (Bit-error rate) within multipath Rayleigh fading channels.

Cluster D (Diversity to Signal-to-interference) focuses on DS-CDMA schemes that utilize coherent Rake combining and SIR (Signal-to-interference power ratio) measurement-based fast TPC (Transmit Power Control).

Cluster E (Noise to Received) focuses on developing algorithms for adaptive antenna arrays with the use of Gaussian noise for testing purposes.

Cluster F (Communications to Range) focuses on digital, personal communications at a global level.

Cluster G (Supporting to Handoff) focuses on management tools that can support QoS (Quality of service) within a wide range of multimedia wireless internet applications.

Cluster H (ATM to Guarantee) focuses on the use of ATM (Asynchronous Transfer Mode) and bandwidth allocation to increase data throughput.

Cluster I (Voice to Layer) focuses on Hop Reservation MAC (Media Access Control) protocols developed for packet-radio networks to insure collision free data transmissions.

Cluster J (Errors to Distributed) focuses on TCP (Transmission Control Protocol), a reliable transport protocol with congestion control that diminishes the number of erroneous packets transmitted.

Cluster K (Nodes to Scheduling) focuses on ad-hoc routing protocols where nodes are only required to keep track of their own position and hop-stations.

Cluster L (Standards to Probability) focuses on the research and development of third-generation Telecommunication system platforms.

Cluster M (Outage to Local) focuses on the output and delay process of voice/data CDMA (Code-Division Multiple Access) that gives priority to local voice calls by blocking out data packets.

Cluster N (Area to Integrated) focuses on the infrastructure of standard IEEE 802.11 wireless local area networks.

Cluster O (Circuits to Components) focuses on CMOS (Complementary Metal Oxide Semiconductor) technology in circuitry and chips.

Cluster P (Filters to Detector) focuses on collision resolution through slotted ALOHA protocol.

Cluster Q (Joint to Propagation) focuses on DS-CDMA (Direct-Sequence Code-Division Multiple Access) equipped with adaptive antenna arrays offering jointly effective spatial and temporal MAI (Multiple Access Interference) and channel noise suppression.

Cluster R (Indoor to Modulation) focuses on the development of techniques to lessen ISI (Intersymbol Interference) within indoor wireless networks.

Cluster S (QPSK to Experiments) focuses on QPSK (Quadrature Phase Shift Keying) being applied to OFDM (Orthogonal Frequency Division Multiplexing) to improve BER.

Cluster T (WIDEBAND to FORWARD) focuses on Field and Laboratory experiments on W-CDMA (Wide-band Code-division Multiple Access) to increase BER (Bit error Rate) by applying STTD (Space Time Transmit Diversity)

Cluster U (Correction to 2.4) focuses on ARQ (Automatic-Repeat-Request) schemes that improve throughput for high-speed packets through transmission repetition.

4.2.1.1.1.2.2 Phrase Multi-link Clustering

The 253 Phrases in the dendrogram are grouped into 22 elemental clusters. These clusters form the lowest level of the taxonomy hierarchy. Each cluster is assigned a letter, ranging from A to V. These lowest level phrase clusters may be interpreted as follows.

Cluster A (SYSTEMS to ISI) focuses on limiting the amount of ISI (Inter-Symbol Interference) within wireless networks.

Cluster B (CDMA SYSTEMS to BIT ERROR RATES) focuses on both CDMA (Code-Division Multiple Access) and TDMA (Time-Division Multiple Access) schemes for minimizing the multiple access problem.

Cluster C (MULTIPATH to FREQUENCY SELECTIVITY) focuses on CDMA's (Code-Division Multiple Access) and OFDM's (Orthogonal Frequency Division Multiplexing) performance and capacity being limited by MAI (Multiple Access Interference).

Cluster D (RAYLEIGH to MULTIUSER DETECTION) focuses on the simulated degradation of performance of DS_CDMA (Direct Sequence Code Division Multiple Access) systems when exposed to flat Rayleigh fading channels.

Cluster E (THROUGHPUT to ALOHA PROTOCOL) focuses on the throughput performance of a direct sequence spread spectrum (DS/SS) slotted ALOHA wireless communication network system with delay capture.

Cluster F (CHANNEL to VOICE ACTIVITY) focuses on the performance of wireless MAC (Media Access Control) protocols with Rayleigh fading, shadowing, and capture effect.

Cluster G (STATIONS to ANALYTICAL MODEL) focuses on the use of analytical models to study standard IEEE 802.11 protocols with a dynamically tuned backoff.

Cluster H (NUMERICAL RESULTS to WAITING TIME) focuses on the use of CDMA (Code-Division Multiple Access) and CSMA (Carrier Sense Multiple Access) protocols to improve signal throughput.

Cluster I (NETWORK NODES to MAXIMUM DOPPLER FREQUENCY) focuses on utilizing innovative Network Nodes to allow robust electronic commerce and real-time image/video transmission.

Cluster J (WIRELESS LINKS to TCP PERFORMANCE) focuses on TCP (Transmission Control Protocol) and UDP (User Datagram Protocol) as a means of sending and receiving signals over an IP (Internet Protocol) network.

Cluster K (BER PERFORMANCE to PACKET SIZE) focuses on the throughput and energy-efficiency of TCP (Transmission Control Protocol) on wireless links using ARQ (Automatic repeat Request) and FEC (Forward Error Correction) protocols.

Cluster L (POWER CONSUMPTION to BATTERY) focuses on low power consumption as being a key design metric for portable wireless network devices where battery energy is a limited resource.

Cluster M (PROTCOLS to BROADCAST) focuses on a medium access control protocol for a packet transmission mobile radio network.

Cluster N (NODES to CONNECTIVITY) focuses on a framework for dynamically organizing mobile nodes in wireless ad hoc networks into clusters in which the probability of path availability can be bounded.

Cluster O (OVERHEAD to MECHANISM) focuses on the overhead and multicast tree problems within standard MANET (Mobile Ad Hoc Networks).

Cluster P (SIMULATION RESULTS to ADMISSION CONTROL) focuses on several simulated schemes based on resource reservation that investigates the performance of a CDMA cellular system, a network supporting integrated data transfer and providing predictable QoS (Qualities of Service).

Cluster Q (CELLS to COMMUNICATION) focuses on future personal communications networks supporting network-wide handoffs, forced call terminations due to handoff call blocking, and the previously proposed guard channel scheme for radio channel allocation in cellular networks reducing handoff call blocking probability.

Cluster R (ATM to MOBILE USER) focuses on the use of ATM (Asynchronous Transfer Mode) for the seamless integration of advanced multimedia services over both fixed and mobile networks leading to fired-mobile convergence.

Cluster S (IP to MOBILE COMMUNICATIONS) focuses on the concept of mobile ATM (Asynchronous Transfer Mode), a proposal for third-generation mobile communication network infrastructure capable of supporting flexible evolution of radio technologies from today's cellular and data services towards future wireless multimedia services.

Cluster T (WIRELESS ACCESS to DATA) focuses on the use of broadband technology to increase the data rate for multimedia, messaging, and high-speed Internet access.

Cluster U (VOICE to EXPERIMENTAL RESULTS) focuses on the performance of DPRMA (Dynamic Packet Reservation Multiple Access) schemes and their ability to perform well in a system with voice, video conferencing, and data users present.

Cluster V (AVERAGE BER to ACCESS) focuses on an outer loop control method of fast TPC (Transmit Power Control) for high-quality data transmission such as that with tile average bit error rate (BER) of 10(-6) in serial concatenated channel coding combining convolutional and Reed-Solomon codings for DS-CDMA mobile radio.

At this point, the relationship between the lowest level factors and clusters, and their aggregation into higher level category clusters, will be examined. Table 9 shows the assignment of factors and individual clusters to the second level categories of the multi-link word clustering-defined taxonomy. The first row represents the highest taxonomy level, and the second row represents the next highest taxonomy level. Each taxonomy category in the second row includes the column in which it is written, plus the adjacent column to the right.

As an example, under the first level category (Improved Throughput protocols/ Physical Layer Limitations), there are two second level categories: Improved Throughput Protocols, and Physical Layer Throughput Limitations. Under the second level category of Improved Throughput Protocols are word clusters (A, B), word factors (10, 11), and phrase factors (5). There is good correspondence between the factors and individual clusters within the higher level categories.

TABLE 9 – FACTOR MATRIX-WORD/ PHRASE CLUSTER TAXONOMY

CLUSTERS (A-E) IMPROVED THROUGHPUT PROTOCOLS/ PHYSICAL LAYER LIMITATIONS				CLUSTERS (F-U) IMPROVED THROUGHPUT ARCHITECTURES			
CLUSTERS (A-B) IMPROVED THROUGHPUT PROTOCOLS		CLUSTERS (C-E) PHYSICAL LAYER THROUGHPUT LIMITATIONS		CLUSTERS (F-P) IMPROVED THROUGHPUT ARCHITECTURES		CLUSTERS (Q-U) SIGNAL PROPAGATION PROTOCOLS TO REDUCE LATENCY	
FACT		FACT		FACT		FACT	
WRD	PHR	WRD	PHR	WRD	PHR	WRD	PHR
10	5	8	8	2	2	1	1
11				3	3	4	
				5	4	12	
				6	6		
				7	7		
				9	9		
					10		
					11		
					12		

4.2.1.1.2 Document Clustering

Document clustering is the grouping of similar documents into thematic categories. Different approaches exist (e.g., Willett, 1988; Rasmussen, 1992; Cutting et al, 1992; Guha et al, 1998; Hearst, 1998; Zamir and Etzioni, 1998; Karypis et al, 1999; Steinbach et al, 2000). Two approaches were examined in this paper: Greedy String Tiling, and Partitional Clustering.

4.2.1.1.2.1 Greedy String Tiling

4.2.1.1.2.1.1 Greedy String Tiling Approach

The approach presented in this section is based on a Greedy String Tiling (GST) text matching algorithm (Wise, 1992; Prechelt et al, 2002). It is described in some detail in Appendix 1. Basically, GST clustering forms groups of documents based on the cumulative sum of shared strings of words. Each group is termed a cluster, and the number of records in each cluster, and the highest frequency technical keywords in each cluster, are two outputs central to this analysis. The shared strings for any pair of documents form the basis for a similarity metric for the pair. Document membership within a cluster is determined by the similarity threshold selected.

4.2.1.1.2.1.2 Greedy String Tiling Results

The similarity metric threshold value was varied from one to twenty percent, within a complete link clustering algorithm. Based on a balance between cluster size and cohesiveness, a four percent similarity threshold was selected. The four percent similarity threshold produced a total of 167 clusters. The 60 largest clusters, containing 1521 Abstracts, were extracted, and are listed by size in Appendix 11, in descending numerical order. The main keywords from each cluster are shown in parentheses after the cluster number, and the number of records in each cluster is shown in parenthesis before the cluster number. The keywords are arranged in frequency of appearance, in descending order. Three levels of filtering were used to obtain the main keywords shown. First, a trivial word list (e.g., of, the, on, etc) was applied to the raw data. Second, only the highest frequency words for each cluster were retained. Third, a manual filtering was performed on the thirty highest words to eliminate low technical content words. The themes of each cluster follow each grouping of words. The taxonomy based on these themes is listed in the section titled Word Clustering Taxonomy, located at the end of the document clustering section.

4.2.1.1.2.2 Partitional Clustering

4.2.1.1.2.2.1 Partitional Clustering Approach

The approach presented in this section is based on a partitional clustering algorithm (Zhao and Karypis, 2004) contained within a software package named CLUTO. Most of CLUTO's clustering algorithms treat the clustering problem as an optimization process that seeks to maximize or minimize a particular clustering criterion function defined either globally or locally over the entire clustering solution space. CLUTO uses a randomized incremental optimization algorithm that is greedy in nature, and has low computational requirements. Twenty-one individual clusters were chosen to correlate with the twenty-one manually determined clusters from earlier in this paper. The twenty-one clusters are listed in Appendix 12. Each cluster is numbered (beginning with zero), and the number of documents In each cluster appears at the beginning of every cluster in parentheses. In parentheses are the most descriptive words in each cluster. Each word within the cluster is followed by a number that represents the percentage of intra-cluster similarity explained by the word.

4.4.2.2.3.4 Word Clustering Taxonomy

The taxonomy defined by the word clustering algorithm is used to categorize the document clusters. Each document cluster was assigned to the most appropriate category in the taxonomy defined by the WINSTAT-generated dendrogram of the last section, based on the theme suggested by the highest frequency technical keywords. The number of records in each taxonomy category from all the clusters in the category was calculated, and is shown in Table 10 for the Greedy String Tiling Results. The same Taxonomy was done for the CLUTO clustering results in Table 11. In these Tables, the top two levels of the taxonomy are presented. The top hierarchical level is composed of Improved Throughput Protocols/ Physical Layer Limitations and Improved Throughput Architectures, and the second hierarchical level is composed of Improved Throughput Protocols, Physical Layer Throughput Limitations, Improved Throughput Architectures, and Signal Propagation Protocols To Reduce Latency. The first column is the cluster number, and the matrix elements are the number of records in the cluster in the specific second-level taxonomy category. The numbers in each second level category are summed, and are summed in turn to give the total number of documents in each of the two first level categories.

4.4.2.2.3.4.1 GREEDY STRING TILING TAXONOMY

Table 10

Cluster #	CLUSTERS (A-E) IMPROVED THROUGHPUT PROTOCOLS/ PHYSICAL LAYER LIMITATIONS		CLUSTERS (F-U) IMPROVED THROUGHPUT ARCHITECTURES	
	CLUSTERS (A-B) IMPROVED THROUGHPUT PROTOCOLS	CLUSTERS (C-E) PHYSICAL LAYER THROUGHPUT LIMITATIONS	CLUSTERS (F-P) IMPROVED THROUGHPUT ARCHITECTURES	CLUSTERS (Q-U) SIGNAL PROPAGATION PROTOCOLS TO REDUCE LATENCY

1	93			
2			62	
3	43			
4			42	
5	42			
6			39	
7				38
8			36	
9		35		
10			34	
11		33		
12			32	
13				30
14		30		
15		30		
16			29	
17			28	
18			28	
19	26			
20	26			
21			26	
22				26
23	25			
24			24	
25			23	
26				23
27			23	
28			22	
29			22	
30			22	
31			22	
32			22	
33			22	
34				21
35			20	
36				20
37			20	
38			20	
39		19		
40			19	
41			18	
42	18			
43				18
44			17	
45			17	
46	16			
47		16		
48				16
49				15
50			15	
51			15	
52		15		

53		16		
54		15		
55			15	
56			14	
57		13		
58		13		
59		13		
60			13	
SUM	289	248	761	207
TOTAL		537		968

Approximately 65% of the records in the 60 GST clusters fall into the higher level category (F-U), Improved Throughput Architectures. The other 35% fall into category (A-E), Improved Throughput Protocols/ Physical Layer Limitations. Category (A-E) breaks into two second level groups, 46% into clusters (C-E), Physical Layer Throughput Limitations, and 54% into clusters (A-B), Improved Throughput Protocols. Category (F-U) also divides into two second level groups, 79% into clusters (F-P), Improved Throughput Architectures, and 21% into clusters (Q-U), Signal Propagation Protocols to Reduce Latency.

4.4.2.2.3.4.2 CLUTO CLUSTERING TAXONOMY

Table 11

Cluster #	CLUSTERS (A-E) IMPROVED THROUGHPUT PROTOCOLS/ PHYSICAL LAYER LIMITATIONS		CLUSTERS (F-U) IMPROVED THROUGHPUT ARCHITECTURES	
	CLUSTERS (A-B) IMPROVED THROUGHPUT PROTOCOLS	CLUSTERS (C-E) PHYSICAL LAYER THROUGHPUT LIMITATIONS	CLUSTERS (F-P) IMPROVED THROUGHPUT ARCHITECTURES	CLUSTERS (Q-U) SIGNAL PROPAGATION PROTOCOLS TO REDUCE LATENCY
0			26	
1	12			
2	18			
3		19		
4		17		
5			25	
6			14	
7				22
8			17	
9			61	
10			25	
11				28
12			43	
13			31	

14				
15				31
16			14	
17				28
18			36	
19			42	
20				17
21				27
22	23			
23				24
24		35		
25				29
26				19
27		34		
28			37	
29		31		
30	29			
31			29	
32			79	
33		60		
34		65		
35	59			
36				30
37			25	
38			37	
39			27	
40			36	
41			39	
42		47		
43				36
44			41	
45	36			
46			60	
47		47		
48	45			
49			58	
50		38		
51			42	
52				38
53	59			
54	67			
55	62			
56			54	
57			29	
58			44	
59			78	
SUM	410	393	1049	329
TOTAL		803		1378

Approximately 63% of the 60 CLUTO clusters fall into the higher level category (F-U), Improved Throughput Architectures. The other 37% fall into category (A-E), Improved Throughput Protocols/ Physical Layer Limitations. Cluster (A-E) breaks into two second level groups, 49% into clusters (C-E), Physical Layer Throughput Limitations, and 51% into clusters (A-B), Improved Throughput Protocols. Cluster (F-U) also divides into two second level groups, 76% into clusters (F-P), Improved Throughput Architectures, and 24% into clusters (Q-U), Signal Propagation Protocols to Reduce Latency.

In the previous taxonomy sections, the higher level categories were defined by the results of the word clustering algorithm. Clusters generated by the two document clustering algorithms were then assigned to these higher level categories for comparison of level of effort determination.

In the following, the higher level categories are defined by the results of the partitioning algorithms, and the themes within these categories are determined by their elemental clusters. The slightly modified perspective of the Wireless LANs database is now summarized.

The major total database theme is research on methods to improve throughput while maintaining Quality-of-Service. In all three clustering approaches used in this study, the top-level categorization appeared to consist of two moderately distinct categories. One (Improved Throughput from Physical Layer Advances) addresses digital spread spectrum modulation techniques (CDMA) to increase throughput and user capacity, and the associated efforts at the physical layer to reduce inherent interference limitations of CDMA on system capacity. The other (Improved Throughput from Protocols and Architectures) covers Network Architecture and Applications designed to improve throughput, including infrastructure, protocols, hardware and applications.

Level 1

IMPROVED THROUGHPUT FROM PHYSICAL LAYER ADVANCES

Reduction of multiple access interference suppression in the spatial domain and in the code domain for CDMA systems, and physical approaches to reduce fading losses and restore signal degradation that occurred at the physical layer.

IMPROVED THROUGHPUT FROM PROTOCOLS AND ARCHITECTURES

Protocols for mobile wireless voice and data traffic ATM networks to avoid packet collisions, reduce call dropping, reduce delays, and increase throughput while maintaining Quality of Service.

At the next categorization level, four categories can be discerned. These categories (underlined), and their key themes (bulletized) are as follows:

Level 2

SIGNAL QUALITY MAINTENANCE

Signal degradation at the physical layer, and use of electronics technology to restore and maintain signal quality.

- Optical wave reflections off walls and columns inside buildings, and propagation measurements

- Antennas, especially micro-strip patch and other arrays, and simulated/ measured beam radiation patterns for reduced electromagnetic interference

- Power amplifiers in the Ghz frequency range for wireless LANs, especially those using CMOS hardware or circuitry

CDMA INTERFERENCE REDUCTION

Reduction of multiple access interference suppression in the spatial domain and in the code domain for CDMA systems, and physical approaches to reduce fading losses

- OFDM (Orthogonal Frequency-Division Multiplexing), especially degradation from frequency offsets, and symbol modification to cut down on ISI (Inter-Symbol Interference) while benefiting from reduced path loss

- Use of DS\CDMA (Direct-Sequence\ Code-Division Multiple Access) systems that improve BER (Bit Error Rate) within Rayleigh multi-path fading channels.

- Diversity, by the use of antenna diversity reception and coherent Rake combiners, in spread-spectrum communications over fast-fading multi-path channels for increasing throughput

- Channel estimation for interference-limited channels, and multi-user detectors for co-channel interference cancellation

- CDMA (Code-Division Multiple Access) to increase system capacity by reducing interference from other users in a cell

- Use of signal-to-interference power ratio (SIR) measurement based fast transmit power control (TPC) to reduce the minimum transmit power according to the channel load and the changes in the link conditions due to fading

PACKET TRAFFIC PROTOCOLS

Access protocols for voice and data traffic that increase throughput and reduce delays by packet collision avoidance (e.g., CSMA).

- TCP (Transmission Control Protocols) employing ARQ/FEC (Automatic Repeat Request/Forward Error Correction) protocols, to reduce packet error

- MAC (Medium Access Control) Protocols, especially TDMA-based, that efficiently accommodate real-time voice and video traffic with dynamic bandwidth/ resource allocation

- Access protocols for integrated voice and data traffic that overcome the heavy load degraded performance due to the contention mechanism of random access in PRMA (Packet Reservation Multiple Access) protocols.

- CSMA (Carrier-Sense Multiple Access) protocols that increase throughput by focusing on packet collision avoidance

NETWORK ARCHITECTURES

Architectures and routing protocols for mobile ad hoc wireless ATM networks to improve Quality of Service.

- Standard IEEE 802.11 MAC (Medium Access Control) protocols for wireless LANs

- Standard Bluetooth IEEE 802.11 wireless LAN devices and technology

- Providing Internet services, with enhanced performance Internet protocols over wireless networks, to mobile communications systems users

- Architectures maintaining guaranteed levels of QoS (Quality of Service) within wireless mobile ATM (Asynchronous Transfer Mode) networks

- Handoffs and connection path rerouting to avoid cell loss to mobile users in ATM (Asynchronous Transfer Mode) networks

- Call handoff management schemes to minimize dropping probability of handoff calls and blocking probability of new calls

- Routing protocols for wireless ad hoc mobile networks

- Multicasting, especially in mobile ad hoc networks with multiple hosts, and the use of multicast delivery trees under mobile host conditions

Approximately 46% of the CLUTO cluster documents are assigned by the partitioning clustering algorithm to the first higher level category, Improved Throughput from Physical Layer Advances, while the other 54% are assigned to the second higher level category, Improved Throughput from Protocols and Architectures. The category Improved Throughput from Physical Layer Advances breaks into two second level categories, with 30% of its documents assigned to the category Signal Quality Maintenance, and 70% assigned to category CDMA Interference Reduction. The other first level cluster, Improved Throughput from Protocols and Architectures, also divides into two second level groups, with 36% of its documents assigned to category Packet Traffic Protocols, and 64% of its records assigned to category Network Architectures.

Finally, Appendix 14 contains the Keywords for Wireless LANs documents retrieved from 1991-2005. The Keywords can be viewed as specific technology thrust areas, with specificity increasing as frequency decreases.

4. SUMMARY AND CONCLUSIONS
(See Executive Summary at Beginning of Report)

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APPENDIX 1 – GREEDY STRING TILING (GST) CLUSTERING

Greedy String Tiling (GST) clustering is a method of grouping text or text character documents (files) by similarity. All documents to be grouped are placed in a database. Each pair of documents is compared by GST, an algorithm originally used to detect plagiarism [Wise, 1992; Prechelt et al, 2002], and a similarity score is assigned to the pair. Then, hierarchical aggregation clustering [Rasmussen, 1992; Steinbach, 2000] is performed on all the documents, using the similarity score for group assignment.

Greedy String Tiling computes the similarity of a pair of documents in two phases. First, all documents to be compared are parsed, and converted into token strings (words or characters). Second, these token strings are compared in pairs for determining the similarity of each pair. During each comparison, the GST algorithm attempts to cover one token string (document) with sub-strings (‘tiles’) taken from the other string. These sub-strings are not allowed to overlap, resulting in a one to one mapping of tokens. The attribute ‘greedy’ stems from the fact that the algorithm matches the longest sub-strings first.

A number of similarity metrics can be defined once the tiling is completed. One similarity metric is the percentage of both token strings that is covered. Another similarity metric is the absolute number of shared tokens. A third similarity metric is the mutual information index. Depending on the purpose of the matching, additional weightings can be used for the similarity matrix to increase the ranking precision. For example, if plagiarism is one study objective, additional weighting could be given to shared string length. All similarity metrics have positive and negative features, and the choice of metric is somewhat influenced by the study objectives and the structure of the database.

Once the document similarity matrix has been generated, myriad clustering techniques can be used to produce a classification scheme (taxonomy). In the present study, multi-link hierarchical aggregation was used. Three clustering variants were actually generated, although the extension to other clustering schemes is straight-forward. Single-link, average-link, and complete-link variants are implemented. The variants differ in how the decision of merging to clusters is made. Single-link requires that the similarity of at least two documents is higher than a certain threshold, while complete-link requires that the similarity between all documents in both clusters be higher than a threshold. Average-link requires that the average pair-wise similarity between the documents of both clusters exceeds the threshold. For the present study, complete-link appeared to give good results, and was the clustering method used.

Appendix 2 – CLUTO Clustering

CLUTO [Karypis, 2002] is a software package that implements various algorithms for clustering low- and high-dimensional datasets and for analyzing the characteristics of the various clusters. CLUTO implements three different classes of clustering algorithms that can operate either directly in the object's feature space or in the object's similarity space. The clustering algorithms provided by CLUTO are based on the partitional, agglomerative, and graph-partitioning paradigms. CLUTO's partitional and agglomerative algorithms are able to find clusters that are primarily globular, whereas its graph-partitioning and some of its agglomerative algorithms are capable of finding transitive clusters.

In this study, documents were clustered using the partitional clustering algorithms provided by CLUTO. Partitional clustering algorithms find the clusters by partitioning the entire document collection into a predetermined number of disjoint sets, each corresponding to a single cluster. This partitioning is achieved by treating the clustering process as an optimization procedure that tries to create high quality clusters according to a particular function that reflects the underlying definition of the "goodness" of the clusters. This function is referred to as the *clustering criterion function.* CLUTO implements seven such criterion functions that measure various aspects of intra-cluster similarity, inter-cluster dissimilarity, and their combinations, and have been shown to produce high-quality clusters in low- and high-dimensional datasets [Zhao and Karypis, 2004].

CLUTO uses two different methods for computing the partitioning clustering solution. The first method computes a *k*-way clustering solution via a sequence of repeated bisections, whereas the second method computes the solution directly (in a fashion similar to traditional *K*-means-based algorithms). These methods are often referred to as *repeated bisecting* and *direct* *k*-way clustering, respectively. CLUTO computes a direct *k*-way clustering as follows. Initially, a set of *k* objects is selected from the datasets to act as the *seeds* of the *k* clusters. Then, for each object, its similarity to these *k* seeds is computed, and it is assigned to the cluster corresponding to its most similar seed. This forms the initial *k*-way clustering. This clustering is then repeatedly refined so that it optimizes a desired clustering criterion function. This optimization is performed using a randomized incremental optimization algorithm that is greedy in nature, has low computational requirements, and produces high-quality solutions [Zhao and Karypis, 2004]. A *k*-way partitioning via repeated bisections is obtained by recursively applying the above algorithm to compute 2-way clustering (*i.e.*, bisections). Initially, the objects are partitioned into two clusters, then one of these clusters is selected and is further bisected, and so on. This process continues *k* - 1 times, leading to *k* clusters. Each of these bisections is performed so that the resulting two-way clustering solution optimizes a particular criterion function.

The actual documents were represented with the widely-used vector-space model. The various terms present in the documents were used to define a high-dimensional space and each document was considered to be a vector in that space. However, unlike the traditional vector-space representation, which relies entirely on single terms, all consecutive two- and three-word combinations were taken into account, resulting in a representation that is capable of capturing the phrases commonly occurring in the documents. In addition, Porter's stemming algorithm was used to pre-process the various terms of each document prior to obtaining their vector-space representation. The weight of each dimension was computed using the TF-IDF model in which terms that occur many times within a document are given higher weight (TF) and terms that occur across many documents were given lower weight (IDF) [Zhao and Karypis, 2004]. The similarity between two documents was measured using the cosine of their corresponding document vectors.

Appendix 3 – Word/ Phrase Clustering Methodology

Phrase clustering is the grouping of word strings by similarity to some metric. When applied to technical literature (unstructured technical text), it produces groups of technical thrusts. The phrase members of each thrust grouping are related to the group's theme. When applied to a bibliometric list, such as a list of technical paper authors, it produces groups of bibliometric quantities (e.g., authors). In the author case, the authors of each group would have some common similarity, depending on the metric chosen. For example, the groups could be defined by people who publish together, or people who work at the same institution, or people who work in the same topical area.

In the present paper, two phrase clustering approaches are used. In both approaches, text to be analyzed is assembled, either from unstructured free text (e.g., reports, databases with free text fields, etc), or databases with bibliometric fields (e.g., databases of journal papers with author name fields, author institution fields, journal fields, etc). The text to be analyzed is then converted to phrases, with a frequency of occurrence associated with each phrase. The physical locations of the phrases in the source documents are retained, so that this co-occurrence information can be exploited in the grouping process.

3A. Statistical Clustering

The statistical clustering approaches start with the phrase frequency and location information, then group phrases based on their co-occurrence frequencies and other important numerical indicators. In previous studies by the first author, the statistical clustering has used two software packages in parallel. In the present report, as discussed in the main body of the text, the factor matrix approach is performed using one software package only, but the multi-link clustering approach still uses both packages. Additionally, the two approaches are performed in tandem, where the factor matrix filtering can be exploited for clustering phrase selection.

The phrase frequency and location information is generated by TechOasis, a software package from Search Technology. TechOasis uses Natural Language Processing (NLP) to extract the phrases and their frequencies from the free text. Not all phrases are extracted (typical of all NLP), and manual cleanup of the extracted phrases is still required to eliminate the lower technical content phrases. Also, unlike the multiple counting of nested phrases in TextSlicer, multiple counting of nested phrases in TechOasis is disallowed (i.e., METAL MATRIX would be counted once as a double word phrase, but neither METAL nor MATRIX would be counted as single word phrases). In previous studies, the resulting phrase frequency and co-occurrence matrix information was then exported from TechOasis to WINSTAT (an Excel add-in software package) for both approaches (described here). Two types of output were generated by WINSTAT: factor matrix and multi-link clustering. Each of these processes will now be described.

3B. Factor Matrix Clustering

Factor matrix clustering generates a correlation matrix from the frequency and location information of the phrases. It then generates factors that are composed of all the phrases in the correlation matrix. The phrases are ordered quantitatively by their correlation with each other, with the most strongly correlated assigned the highest quantitative values.

Appendix 4 shows an author factor matrix. The grouping metric was the number of co-authored publications, taking into account the total number of publications of each author. In order to display all factors on one page width, the column widths had to be shrunk drastically. The matrix element values were hidden, but the shadings could be displayed, and they represent high correlation values (factor loadings). The darker the shading, the higher the value.

The number of factors generated can be fully discretionary (e.g., select a ten factor matrix, with no floor on the eigenvalues), or partially discretionary (e.g., set an eigenvalue floor of unity, let the algorithm generate the final number of factors). Final taxonomies can be generated by manually combining factors into categories, or specifying the number of categories (factors) desired to the algorithm.

The author factor matrix in Appendix 4 was generated by selecting an eigenvalue floor of unity. In practice, this means that each factor generated will add new information. Analysis of the author factor matrix in Appendix 4 is explained in the author bibliometrics section of the text, and will not be repeated here.

A phrase factor matrix looks identical to the author factor matrix, with the exception that the author names are replaced by technical phrases extracted from the free text field analyzed. Appendix 7 contains a word factor matrix, and Appendix 8 contains a phrase factor matrix.

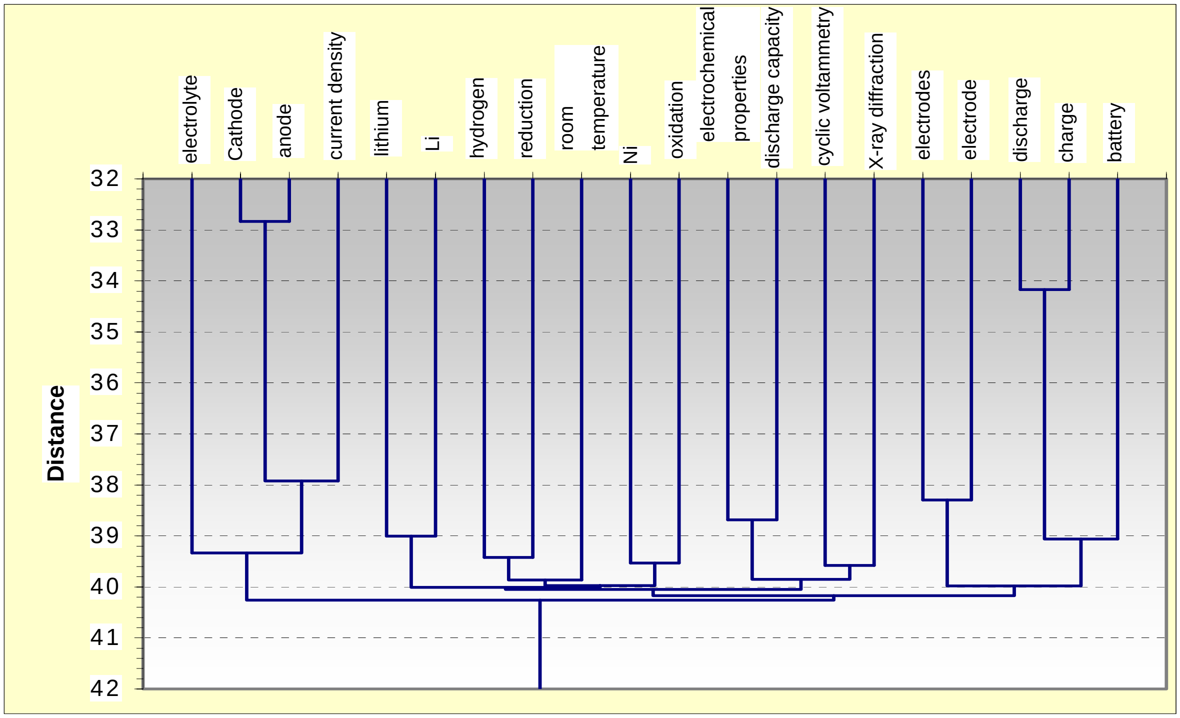
3C. Multi-Link Clustering

Phrase multi-link clustering starts with pre-defined metrics (variables), and groups phrases (cases) based on the strength of their relationships with these metrics. For example, if a symmetric phrase-phrase matrix is used as the basis for clustering, then the closeness of two phrases (cases) will be determined by their co-occurrence profile with all other phrases (variables). The clustering becomes a co-occurrence profile matching process. The WINSTAT software package produces three types of related outputs.

1) A dendrogram that shows the quantitative linkages among closely-related phrases. Figure 3C-1, for example, is a dendrogram that portrays linkages among the twenty highest frequency technical content phrases from a database of Electrochemistry paper Abstracts.

   A dendrogram is a tree-like structure that shows linkages among phrases. It does so by starting with a root that encompasses all the phrases (See the vertical line on Figure 3C-1 ranging from a Distance value of 42 to slightly over 40). Then it splits into two groups (clusters) until all the phrases are contained in their own cluster. In Figure 3C-1, the root at the bottom of the page encompasses all the phrases. The first split is into two large clusters. One cluster contains the phrases ELECTROLYTE, CELL, CATHODE, ANODE, and CELLS. The second cluster contains all the remaining phrases LITHIUM, ELECTROCHEMICAL PROPERTIES, CYCLIC VOLTAMMETRY, X-RAY DIFFRACTION, ELECTRODES, ELECTRODE, HYDROGEN, ALLOY, ALLOYS, BATTERY, AIR, OXYGEN, OXIDATION, WATER, and CONDUCTIVITY.

FIGURE 3C-1 – EXAMPLE TWENTY PHRASE DENDROGRAM



2) A table that contains a quantitative measure of the similarity of adjoining phrases or phrase-cluster pairs. The similarity, or 'distance', is obtained by matching the profiles as described above. Figure 3C-2, for example, is a table that contains the information portrayed in Figure 3C-1. The distances shown on the dendrogram are taken from the distances given in this table; thus, the table is the numerical expression of the dendrogram.

FIGURE 3C-2 – ELEMENTAL STEPS IN DENDROGRAM FORMATION

joining Cluster 1	Size 1	with Cluster 2	Size 2	Distance
Cathode	1	anode	1	32.83216927
discharge	1	charge	1	34.16843369
Cathode	2	current density	1	37.9232786
electrodes	1	electrode	1	38.29297045
electrochemical properties	1	discharge capacity	1	38.68748862

lithium	1	Li	1	39.00662295
discharge	2	battery	1	39.06016967
electrolyte	1	Cathode	3	39.33157288
hydrogen	1	reduction	1	39.42153664
Ni	1	oxidation	1	39.52735747
cyclic voltammetry	1	X-ray diffraction	1	39.58094847
electrochemical properties	2	cyclic voltammetry	2	39.85159646
hydrogen	2	room temperature	1	39.86541946
hydrogen	3	Ni	2	39.97396716
electrodes	2	discharge	3	39.97805457
lithium	2	hydrogen	5	40.00961352
lithium	7	electrochemical properties	4	40.04779843
lithium	11	electrodes	5	40.17291601
electrolyte	4	lithium	16	40.26135359

3) A taxonomy of a pre-specified number of groups of phrases. Figure 3C-3, for example, shows the groupings of phrases when four clusters were specified for the data portrayed in Figure 3C-1.

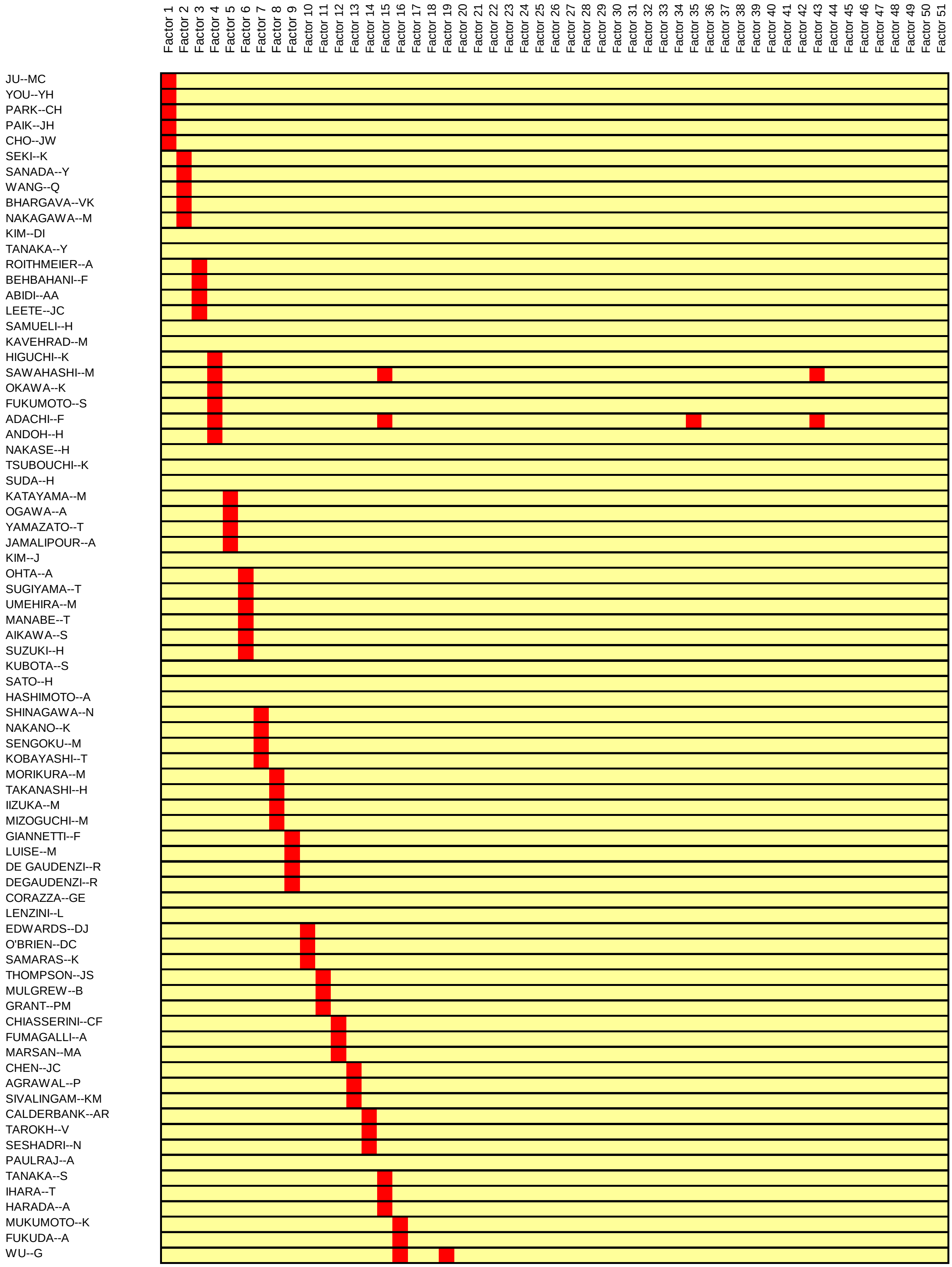
FIGURE 3C-3

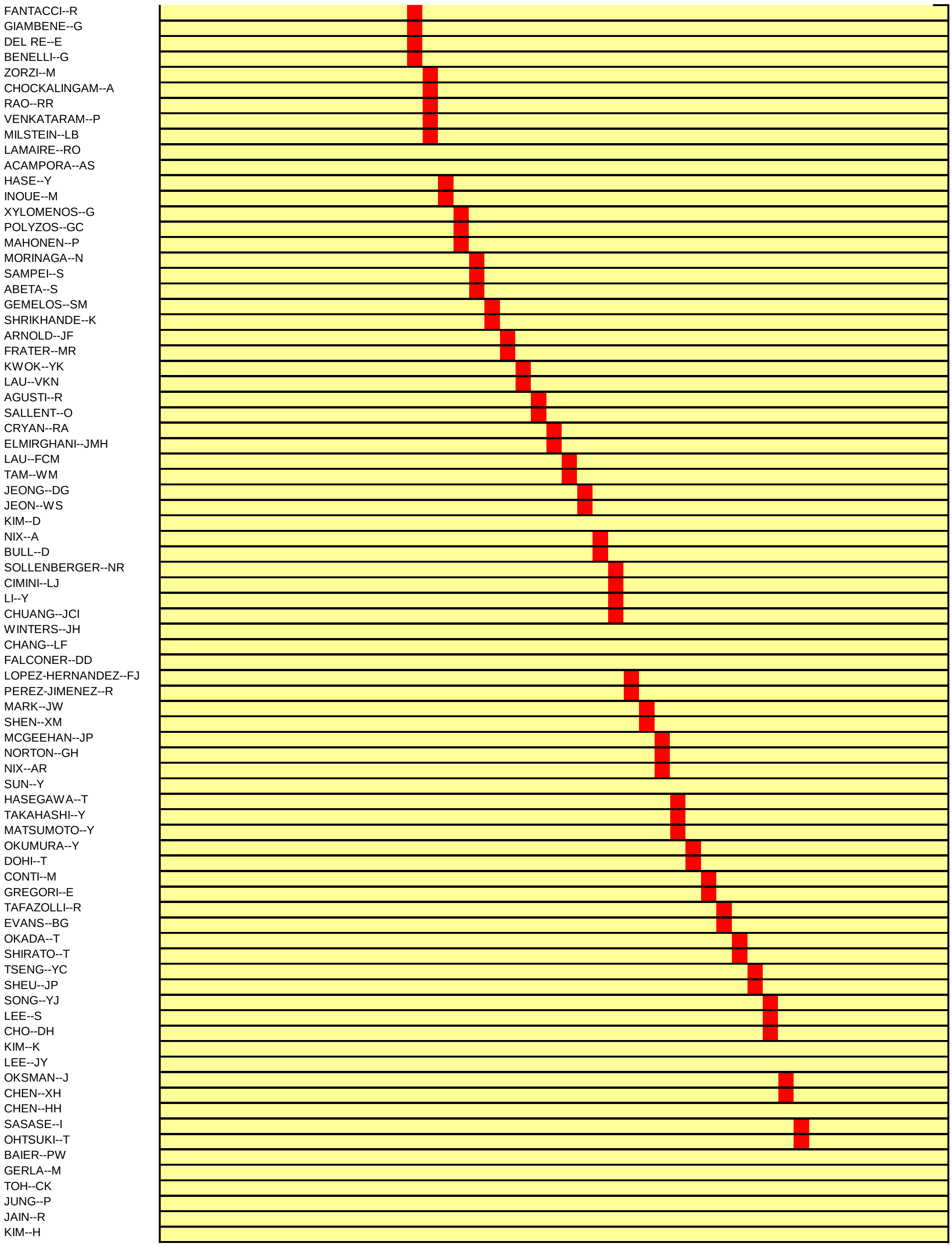
Cluster #	**Phrases**
1	electrolyte
2	lithium
3	electrodes
3	electrode
2	Li
1	Cathode
2	hydrogen
2	room temperature
4	electrochemical properties
4	cyclic voltammetry
2	reduction
1	anode

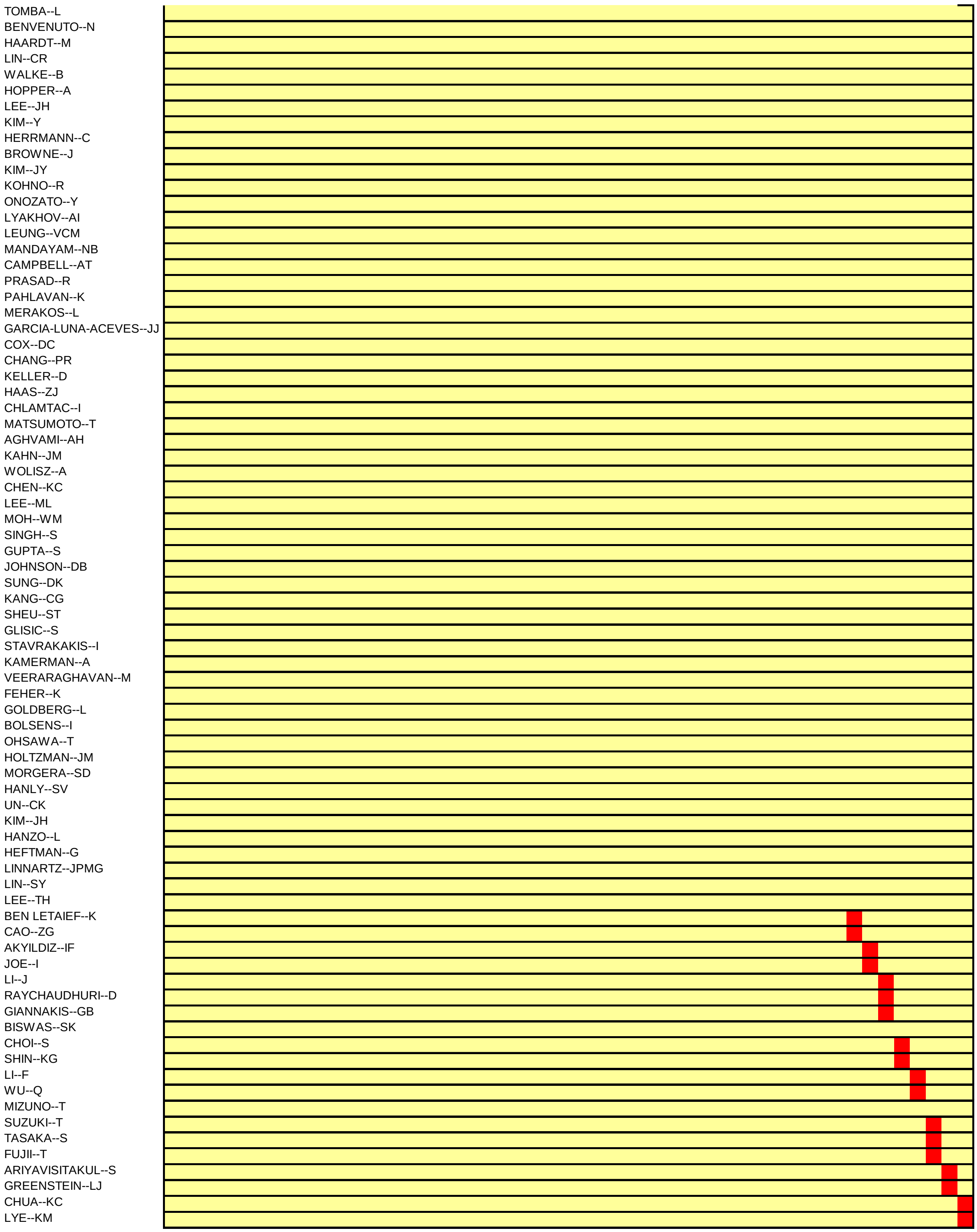
3	discharge
4	X-ray diffraction
2	Ni
4	discharge capacity
3	battery
3	charge
2	oxidation
1	current density

Final categories can be generated two ways. The clusters can be manually grouped into categories. Or, the number of categories (clusters) can be specified to the algorithm, and the computer output will contain the final categories. Usually, some modest manual re-grouping of the computer output groups is required to arrive at a final recommended taxonomy.

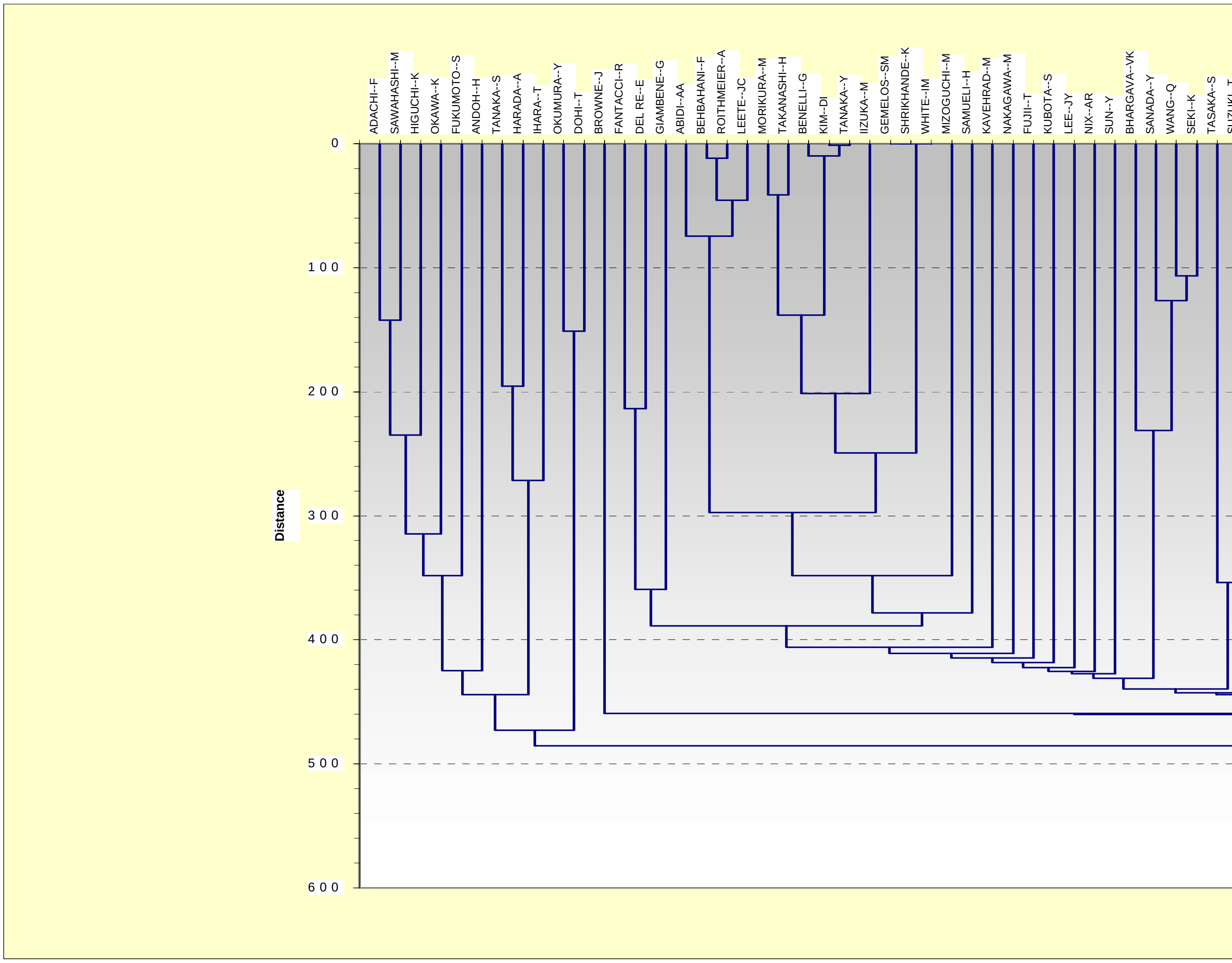
Appendix 4 – Author Factor Matrix

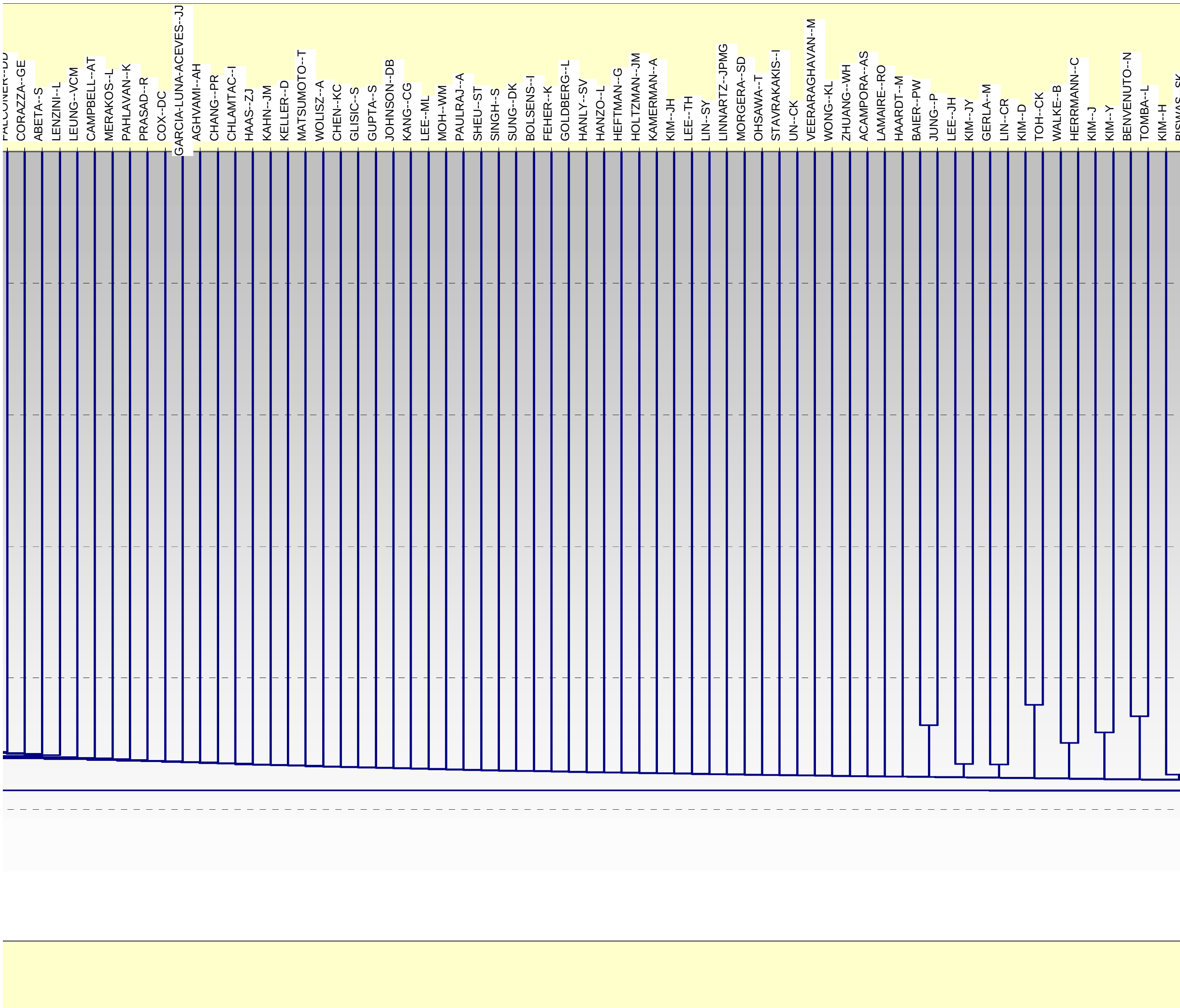



FANTACCI--R
GIAMBENE--G
DEL RE--E
BENELLI--G
ZORZI--M
CHOCKALINGAM--A
RAO--RR
VENKATARAM--P
MILSTEIN--LB
LAMAIRE--RO
ACAMPORA--AS
HASE--Y
INOUE--M
XYLOMENOS--G
POLYZOS--GC
MAHONEN--P
MORINAGA--N
SAMPEI--S
ABETA--S
GEMELOS--SM
SHRIKHANDE--K
ARNOLD--JF
FRATER--MR
KWOK--YK
LAU--VKN
AGUSTI--R
SALLENT--O
CRYAN--RA
ELMIRGHANI--JMH
LAU--FCM
TAM--WM
JEONG--DG
JEON--WS
KIM--D
NIX--A
BULL--D
SOLLENBERGER--NR
CIMINI--LJ
LI--Y
CHUANG--JCI
WINTERS--JH
CHANG--LF
FALCONER--DD
LOPEZ-HERNANDEZ--FJ
PEREZ-JIMENEZ--R
MARK--JW
SHEN--XM
MCGEEHAN--JP
NORTON--GH
NIX--AR
SUN--Y
HASEGAWA--T
TAKAHASHI--Y
MATSUMOTO--Y
OKUMURA--Y
DOHI--T
CONTI--M
GREGORI--E
TAFAZOLLI--R
EVANS--BG
OKADA--T
SHIRATO--T
TSENG--YC
SHEU--JP
SONG--YJ
LEE--S
CHO--DH
KIM--K
LEE--JY
OKSMAN--J
CHEN--XH
CHEN--HH
SASASE--I
OHTSUKI--T
BAIER--PW
GERLA--M
TOH--CK
JUNG--P
JAIN--R
KIM--H


TOMBA--L
BENVENUTO--N
HAARDT--M
LIN--CR
WALKE--B
HOPPER--A
LEE--JH
KIM--Y
HERRMANN--C
BROWNE--J
KIM--JY
KOHNO--R
ONOZATO--Y
LYAKHOV--AI
LEUNG--VCM
MANDAYAM--NB
CAMPBELL--AT
PRASAD--R
PAHLAVAN--K
MERAKOS--L
GARCIA-LUNA-ACEVES--JJ
COX--DC
CHANG--PR
KELLER--D
HAAS--ZJ
CHLAMTAC--I
MATSUMOTO--T
AGHVAMI--AH
KAHN--JM
WOLISZ--A
CHEN--KC
LEE--ML
MOH--WM
SINGH--S
GUPTA--S
JOHNSON--DB
SUNG--DK
KANG--CG
SHEU--ST
GLISIC--S
STAVRAKAKIS--I
KAMERMAN--A
VEERARAGHAVAN--M
FEHER--K
GOLDBERG--L
BOLSENS--I
OHSAWA--T
HOLTZMAN--JM
MORGERA--SD
HANLY--SV
UN--CK
KIM--JH
HANZO--L
HEFTMAN--G
LINNARTZ--JPMG
LIN--SY
LEE--TH
BEN LETAIEF--K
CAO--ZG
AKYILDIZ--IF
JOE--I
LI--J
RAYCHAUDHURI--D
GIANNAKIS--GB
BISWAS--SK
CHOI--S
SHIN--KG
LI--F
WU--Q
MIZUNO--T
SUZUKI--T
TASAKA--S
FUJII--T
ARIYAVISITAKUL--S
GREENSTEIN--LJ
CHUA--KC
LYE--KM

Appendix 5 – Prolific Author Dendrogram

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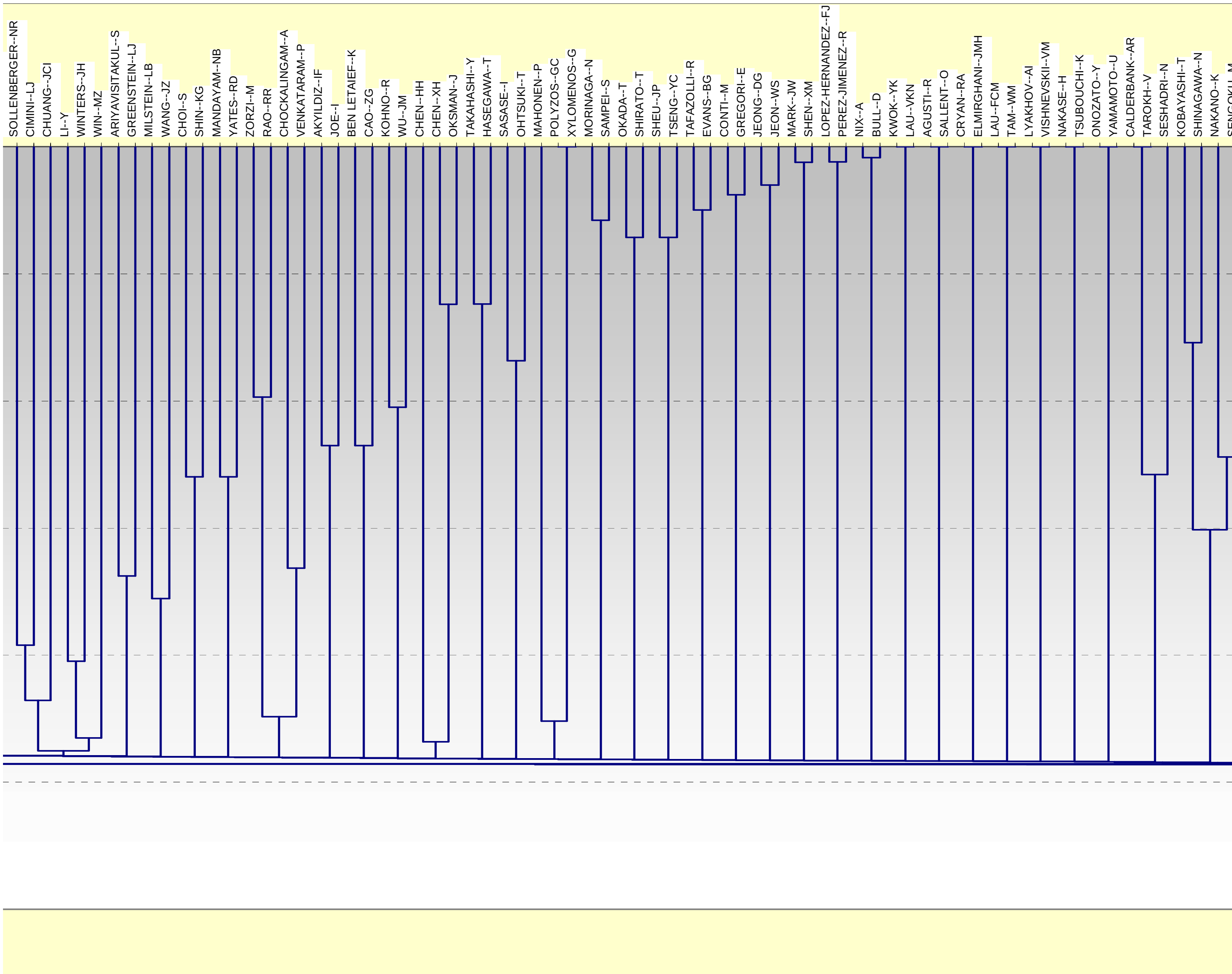
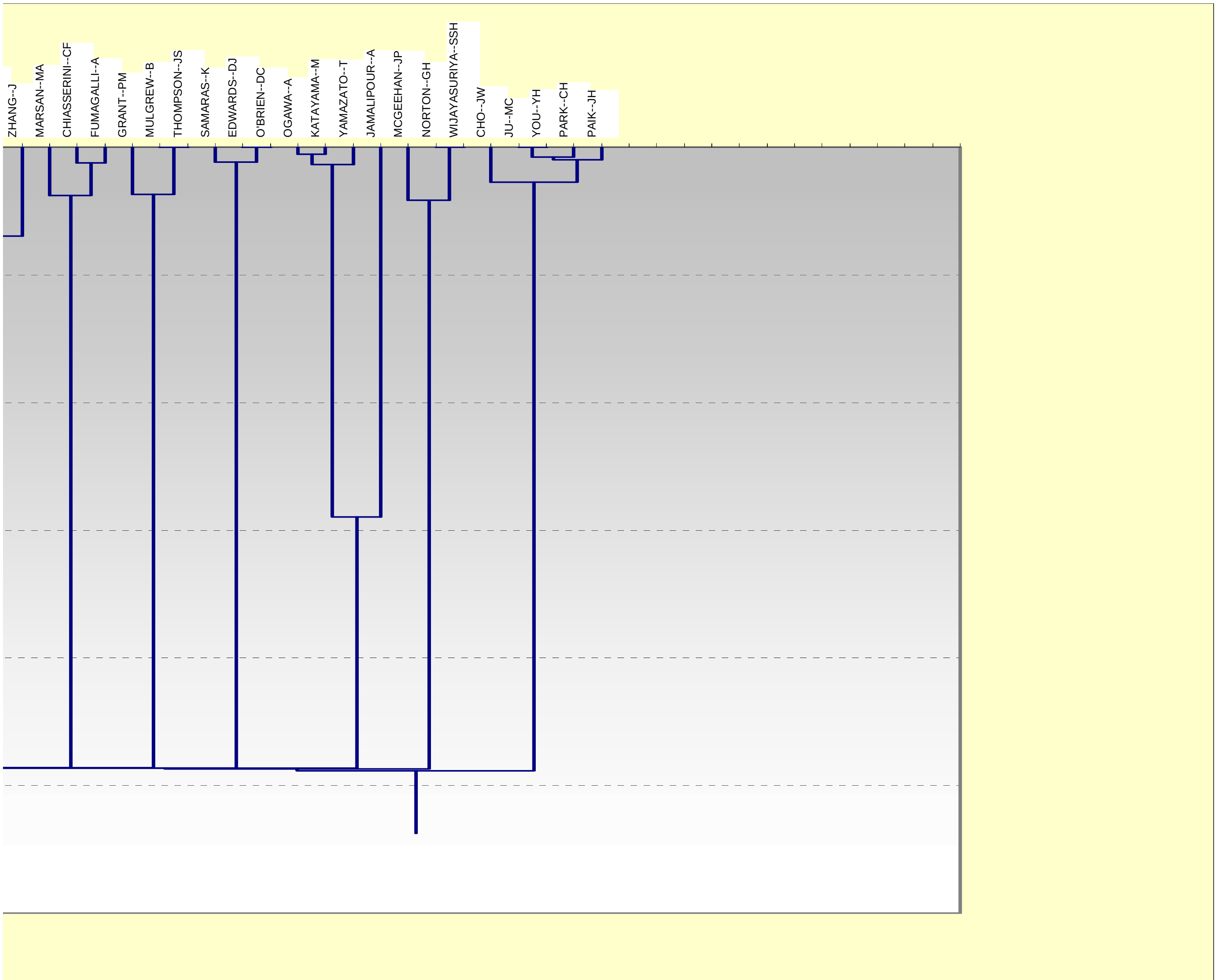
LENZINI--L
LEUNG--VCM
CAMPBELL--AT
MERAKOS--L
PAHLAVAN--K
PRASAD--R
COX--DC
GARCIA-LUNA-ACEVES--JJ
AGHVAMI--AH
CHANG--PR
CHLAMTAC--I
HAAS--ZJ
KAHN--JM
KELLER--D
MATSUMOTO--T
WOLISZ--A
CHEN--KC
GLISIC--S
GUPTA--S
JOHNSON--DB
KANG--CG
LEE--ML
MOH--WM
PAULRAJ--A
SHEU--ST
SINGH--S
SUNG--DK
BOLSENS--I
FEHER--K
GOLDBERG--L
HANLY--SV
HANZO--L
HEFTMAN--G
HOLTZMAN--JM
KAMERMAN--A
KIM--JH
LEE--TH
LIN--SY
LINNARTZ--JPMG
MORGERA--SD
OHSAWA--T
STAVRAKAKIS--I
UN--CK
VEERARAGHAVAN--M
WONG--KL
ZHUANG--WH
ACAMPORA--AS
LAMAIRE--RO
HAARDT--M
BAIER--PW
JUNG--P
LEE--JH
KIM--JY
GERLA--M
LIN--CR
KIM--D
TOH--CK
WALKE--B
HERRMANN--C
KIM--J
KIM--Y
BENVENUTO--N
TOMBA--L
KIM--H
BISWAS--SK


SOLLENBERGER--NR
CIMINI--LJ
CHUANG--JCI
LI--Y
WINTERS--JH
WIN--MZ
ARIYAVISITAKUL--S
GREENSTEIN--LJ
MILSTEIN--LB
WANG--JZ
CHOI--S
SHIN--KG
MANDAYAM--NB
YATES--RD
ZORZI--M
RAO--RR
CHOCKALINGAM--A
VENKATARAM--P
AKYILDIZ--IF
JOE--I
BEN LETAIEF--K
CAO--ZG
KOHNO--R
WU--JM
CHEN--HH
CHEN--XH
OKSMAN--J
TAKAHASHI--Y
HASEGAWA--T
SASASE--I
OHTSUKI--T
MAHONEN--P
POLYZOS--GC
XYLOMENOS--G
MORINAGA--N
SAMPEI--S
OKADA--T
SHIRATO--T
SHEU--JP
TSENG--YC
TAFAZOLLI--R
EVANS--BG
CONTI--M
GREGORI--E
JEONG--DG
JEON--WS
MARK--JW
SHEN--XM
LOPEZ-HERNANDEZ--FJ
PEREZ-JIMENEZ--R
NIX--A
BULL--D
KWOK--YK
LAU--VKN
AGUSTI--R
SALLENT--O
CRYAN--RA
ELMIRGHANI--JMH
LAU--FCM
TAM--WM
LYAKHOV--AI
VISHNEVSKII--VM
NAKASE--H
TSUBOUCHI--K
ONOZATO--Y
YAMAMOTO--U
CALDERBANK--AR
TAROKH--V
SESHADRI--N
KOBAYASHI--T
SHINAGAWA--N
NAKANO--K
SENGOKU--M


ZHANG--J
MARSAN--MA
CHIASSERINI--CF
FUMAGALLI--A
GRANT--PM
MULGREW--B
THOMPSON--JS
SAMARAS--K
EDWARDS--DJ
O'BRIEN--DC
OGAWA--A
KATAYAMA--M
YAMAZATO--T
JAMALIPOUR--A
MCGEEHAN--JP
NORTON--GH
WIJAYASURIYA--SSH
CHO--JW
JU--MC
YOU--YH
PARK--CH
PAIK--JH

Appendix 6 – Country Co-Occurrence Matrix – 1991 – mid-2002

		50	112	114	36	37	124	42	129	361	48	49	59	146	118	746
		AUSTRALIA	CANADA	ENGLAND	FINLAND	FRANCE	GERMANY	GREECE	ITALY	JAPAN	NETHERLANDS	PEOPLES R CHINA	SINGAPORE	SOUTH KOREA	TAIWAN	USA
50	AUSTRALIA	50	0	2	1	0	0	0	0	5	0	0	1	0	0	9
112	CANADA	0	112	1	0	0	1	1	3	3	1	2	1	1	0	12
114	ENGLAND	2	1	114	3	1	4	3	6	1	1	0	2	0	0	4
36	FINLAND	1	0	3	36	1	3	2	3	1	1	1	5	0	1	1
37	FRANCE	0	0	1	1	37	4	0	1	3	0	0	0	0	0	3
124	GERMANY	0	1	4	3	4	124	0	2	3	0	1	0	0	0	9
42	GREECE	0	1	3	2	0	0	42	1	0	0	0	0	0	0	2
129	ITALY	0	3	6	3	1	2	1	129	1	9	0	0	0	0	21
361	JAPAN	5	3	1	1	3	3	0	1	361	2	3	1	1	0	18
48	NETHERLANDS	0	1	1	1	0	0	0	9	2	48	0	0	0	0	5
49	PEOPLES R CHINA	0	2	0	1	0	1	0	0	3	0	49	2	0	1	5
59	SINGAPORE	1	1	2	5	0	0	0	0	1	0	2	59	0	2	5
146	SOUTH KOREA	0	1	0	0	0	0	0	0	1	0	0	0	146	0	12
118	TAIWAN	0	0	0	1	0	0	0	0	0	0	1	2	0	118	8
746	USA	9	12	4	1	3	9	2	21	18	5	5	5	12	8	746

Appendix 7 – Word Factor Matrix

Factor	1	2	3	4	5	6	7	8	9	10	11	12
ARQ	0.514	0.004	0.072	0.109	0.021	0.054	0.08	0.006	0.033	0.001	0.011	0.004
error	0.434	0.075	0.095	0.155	0.008	0.058	0.016	0.173	0.119	0.119	0.024	0.276
automatic	0.428	0.003	0.048	0.102	0.03	0.004	0.089	0.002	0.035	0.026	0.027	0.008
Correction	0.391	0.057	0.033	0.071	0.028	0.034	0.013	0.003	0.05	0.006	0.072	0.123
retransmission	0.355	0.079	0.078	0.082	0.023	0.046	0.079	0	0.065	0.049	0.009	0.012
request	0.341	0.132	0.059	0.102	0.06	0.037	0.001	0.029	0.012	0.007	0.049	0.006
bit	0.324	0.03	0.045	0.082	0.078	0.007	0.079	0.117	0.128	0.037	0.067	0.247
data	0.312	0.239	0.188	0.065	0.092	0.042	0.016	0.015	0.003	0.037	0.051	0.077
link	0.31	0.081	0.019	0.047	0	0.031	0.137	0.283	0.013	0.064	0.113	0.09
rate	0.304	0.033	0.029	0.107	0.115	0.045	0.135	0.133	0.096	0.047	0.053	0.254
transport	0.303	0.031	0.132	0.041	0.013	0.027	0.135	0.09	0.089	0.051	0.064	0.041
throughput	0.299	0.338	0.088	0.106	0.067	0.067	0.097	0.02	0.032	0.184	0.086	0.035
errors	0.292	0.037	0.072	0.024	0.021	0.039	0.013	0.025	0.026	0.033	0.001	0.055
TCP	0.289	0.067	0.004	0.024	0.002	0.057	0.023	0.041	0.136	0.026	0.099	0.1
forward	0.285	0.028	0.011	0.074	0.018	0.023	0.049	0.184	0.029	0.01	0.151	0.034
layer	0.282	0.038	0.142	0.038	0.055	0.053	0.041	0.009	0.05	0.068	0.134	0.077
links	0.268	0.084	0.049	0.021	0.005	0.042	0.047	0.043	0.123	0.001	0.033	0.035
coding	0.266	0.039	0.026	0.049	0.053	0.007	0.016	0.137	0.041	0.041	0.053	0.203
transmission	0.266	0.22	0.034	0.039	0.015	0.034	0.001	0.088	0.022	0.005	0.058	0.134
packet	0.258	0.345	0.033	0.09	0.034	0.082	0.033	0.009	0.164	0.095	0.024	0.022
transfer	0.256	0.045	0.069	0.018	0.091	0.022	0.289	0.161	0.038	0.065	0.051	0.006
fading	0.255	0.148	0.105	0.242	0.095	0.111	0.058	0.309	0.088	0.177	0.103	0.29
video	0.245	0.107	0.151	0.007	0.028	0.007	0.104	0.089	0.068	0.073	0.015	0.017
congestion	0.231	0.009	0.058	0.004	0.005	0.017	0.125	0.072	0.115	0.039	0.002	0.101
loss	0.22	0.032	0.054	0.014	0.024	0.02	0.188	0.027	0.007	0.205	0.011	0.052
ATM	0.218	0.007	0.151	0.075	0.131	0.078	0.45	0.244	0.062	0.067	0.077	0.018
control	0.215	0.284	0.001	0.082	0.015	0.027	0.246	0.115	0.043	0.06	0.149	0.099
unit	0.212	0.015	0.007	0.063	0.031	0.085	0.055	0.031	0.017	0.029	0.051	0.097
BER	0.21	0.096	0.093	0.119	0.018	0.011	0.061	0.311	0.097	0.002	0.035	0.199
reliable	0.204	0.038	0.018	0.067	0.008	0.03	0.017	0.051	0.116	0.018	0.073	0.002
selective	0.204	0.064	0.054	0.082	0.029	0.033	0.076	0.104	0.035	0.027	0.035	0.169
channel	0.203	0.197	0.099	0.222	0.082	0.064	0.001	0.164	0.083	0.169	0.112	0.224
wireless	0.201	0.145	0.275	0.075	0.002	0.083	0.091	0.182	0.085	0.011	0.221	0.01
MAC	0.041	0.46	0.043	0.033	0.05	0.054	0.01	0.031	0.011	0.016	0.158	0.043
collision	0.094	0.444	0.068	0.053	0.035	0.047	0.136	0.024	0.035	0.073	0.102	0.024
access	0.036	0.441	0.235	0.026	0.007	0.104	0.009	0.085	0.116	0.059	0.235	0.108
protocol	0.178	0.429	0.072	0.188	0.098	0.14	0.022	0.106	0.268	0.008	0.13	0.091
traffic	0.107	0.413	0.01	0.103	0.023	0.077	0.281	0.147	0.06	0.055	0.108	0.07
contention	0.019	0.411	0.016	0.011	0.01	0.027	0.024	0.02	0.023	0.029	0.053	0.003
medium	0.04	0.365	0.086	0.048	0.039	0.039	0.015	0.015	0.006	0.001	0.104	0.015
reservation	0.014	0.352	0.024	0.087	0.071	0.056	0.113	0.103	0.045	0.022	0.075	0.012
priority	0.029	0.321	0.063	0.067	0.059	0.044	0.111	0.088	0.003	0.022	0.063	0.009
slots	0.012	0.313	0.054	0.047	0.063	0.021	0.073	0.057	0.009	0.062	0.073	0.036
IEEE	0.035	0.295	0.147	0.023	0.017	0.026	0.135	0.041	0.009	0.06	0.332	0.011
load	0.05	0.291	0.053	0.01	0.007	0.024	0.087	0.051	0.05	0.053	0.061	0.043
multiple	0.079	0.289	0.031	0.08	0.001	0.049	0.016	0.153	0.1	0.115	0.357	0.196
slot	0.007	0.288	0.045	0.019	0.085	0.009	0.031	0.064	0.016	0.029	0.025	0.039
delay	0.14	0.285	0.132	0.011	0.071	0.058	0.115	0.025	0.017	0.182	0.07	0.07
voice	0.089	0.271	0.139	0.115	0.113	0.044	0.103	0.122	0.065	0.003	0.123	0.031
packets	0.178	0.263	0.108	0.084	0.056	0.042	0.063	0.005	0.243	0.022	0.005	0.001
sense	0.098	0.257	0.002	0.065	0.022	0.038	0.123	0.052	0.007	0.127	0.067	0.057
802.11	0.02	0.257	0.098	0.005	0.002	0.014	0.112	0.035	0.008	0.056	0.291	0.022
time	0.042	0.249	0.015	0.159	0.009	0.007	0.078	0.009	0.073	0.155	0.045	0.034
CSMA/CD	0.112	0.245	0.1	0.066	0.082	0.046	0.135	0.005	0.041	0.12	0.169	0.055
ALOHA	0.014	0.241	0.086	0.077	0.041	0.071	0.081	0.007	0.021	0.143	0.005	0.001
station	0.066	0.238	0.019	0.048	0.013	0.022	0.055	0.179	0.038	0.076	0.265	0.235
real-time	0.059	0.236	0.041	0.019	0.044	0.022	0.098	0.071	0.036	0.008	0.039	0.04
slotted	0.016	0.232	0.061	0.073	0.005	0.055	0.09	0.003	0.058	0.142	0.019	0.014
frame	0.135	0.223	0.048	0.001	0.003	0.026	0.01	0.001	0.036	0.028	0.007	0.065
local	0.083	0.222	0.111	0.075	0.036	0.116	0.09	0.018	0.006	0.109	0.223	0.013
simulation	0.112	0.22	0.117	0.07	0.047	0.073	0.068	0.081	0.128	0.046	0.05	0.064
terminals	0.046	0.22	0.088	0.04	0.011	0.006	0.004	0.026	0.014	0.019	0.031	0.058
transmit	0.08	0.208	0.067	0.001	0.045	0.098	0.077	0.383	0.011	0.094	0.055	0.026
length	0.114	0.206	0.092	0.002	0.018	0.017	0.02	0.063	0.024	0.017	0.004	0.034
allocation	0.011	0.206	0.03	0.023	0.018	0.009	0.232	0.135	0.004	0.01	0.136	0.01
scheduling	0.046	0.202	0.011	0.016	0.064	0.043	0.11	0.052	0.042	0.024	0.019	0.006
resolution	0.049	0.201	0.039	0.059	0.052	0.013	0.016	0.012	0.025	0.013	0.042	0.002
assignment	0.045	0.201	0.019	0.052	0.058	0.006	0.076	0.029	0.008	0.001	0.09	0.013
based	0.006	0.2	0.086	0.115	0.092	0.02	0.146	0.089	0.064	0.05	0.03	0.07
services	0.106	0.093	0.492	0.09	0.03	0.064	0.181	0.114	0.007	0.083	0.068	0.021
Internet	0.098	0.069	0.372	0.095	0.055	0.087	0.008	0.039	0.163	0.108	0.054	0.067
Technologies	0.014	0.044	0.36	0.042	0.015	0.004	0.033	0.008	0.017	0.13	0.011	0.048

service	0.097	0.093	0.355	0.105	0.043	0.07	0.293	0.147	0.042	0.012	0.042	0.061
telecommunications	0.022	0.02	0.344	0.062	0.003	0.029	0.005	0.014	0.047	0.025	0.021	0.027
future	0.031	0.047	0.334	0.013	0.042	0.016	0.049	0.048	0.036	0.042	0.037	0.027
issues	0.018	0.041	0.318	0.032	0.07	0.047	0.037	0.039	0.017	0.008	0.062	0.002
technical	0.027	0.024	0.317	0.051	0.002	0.047	0.015	0.021	0.06	0.019	0.038	0.019
research	0.007	0.007	0.314	0.037	0.096	0.001	0.045	0.031	0.023	0.021	0.042	0.036
broadband	0.022	0.052	0.313	0.026	0.015	0.015	0.152	0.053	0.121	0.045	0.113	0.077
technology	0.054	0.053	0.307	0.039	0.008	0.243	0.031	0.03	0.014	0.093	0.068	0.042
IP	0.043	0.07	0.304	0.082	0.026	0.12	0.085	0.059	0.181	0.085	0.072	0.003
multimedia	0.121	0.151	0.3	0.041	0.043	0.03	0.205	0.134	0.018	0.056	0.06	0.046
article	0.055	0.051	0.298	0.092	0.088	0.057	0.023	0.001	0.093	0.103	0.09	0.082
support	0.032	0.079	0.296	0.05	0.036	0.07	0.18	0.102	0.206	0.046	0.057	0.008
standardization	0.054	0.054	0.29	0.034	0.052	0.058	0.026	0.007	0.048	0.047	0.062	0.021
standards	0.044	0.042	0.285	0.054	0.034	0.04	0.099	0.005	0.024	0.06	0.08	0.006
communications	0.048	0.002	0.283	0.058	0.052	0.036	0.099	0.016	0.058	0.038	0.119	0.076
Generation	0.049	0.071	0.279	0.034	0.065	0.005	0.007	0.055	0.04	0.043	0.123	0.019
infrastructure	0.083	0.004	0.278	0.063	0.04	0.045	0.041	0.027	0.229	0.029	0.009	0.022
applications	0.033	0.016	0.27	0.006	0.022	0.173	0.041	0.094	0.09	0.024	0.037	0.018
growth	0.013	0.006	0.267	0.002	0.014	0.006	0.024	0.004	0.02	0.007	0.006	0.056
third-generation	0.019	0.01	0.264	0.046	0.135	0.007	0.052	0.017	0.015	0.062	0.13	0.002
systems	0.045	0.024	0.263	0.228	0.088	0.006	0.076	0	0.134	0.093	0.211	0.086
major	0.018	0.016	0.262	0.043	0.021	0.013	0.059	0.035	0.046	0.019	0.041	0.007
mobile	0.003	0.104	0.261	0.005	0.116	0.065	0.089	0.108	0.213	0.012	0.36	0.041
market	0.022	0.028	0.259	0.054	0.055	0.01	0.049	0.006	0.014	0.044	0.042	0.015
universal	0.002	0.034	0.254	0.034	0.023	0.015	0.041	0.015	0.012	0.016	0.053	0.017
world	0.028	0.014	0.25	0.045	0.004	0.011	0.034	0.012	0.004	0.029	0.04	0.021
network	0.018	0.15	0.248	0.144	0.185	0.054	0.195	0.124	0.32	0.097	0.118	0.081
advanced	0.048	0.04	0.246	0.006	0.035	0.008	0.022	0.011	0.055	0.048	0.1	0.021
personal	0	0.032	0.241	0.034	0.012	0.086	0.098	0.019	0.003	0.029	0.098	0.043
Global	0.054	0.036	0.236	0.02	0.012	0.009	0.047	0.001	0.085	0.022	0.098	0.035
seamless	0.052	0.031	0.236	0.064	0.039	0.038	0.091	0.046	0.029	0.054	0.042	0.025
European	0.054	0.018	0.236	0.027	0.02	0.01	0.02	0.012	0.092	0.003	0.045	0.005
radio	0.1	0.028	0.235	0.045	0.048	0.039	0.067	0.137	0.074	0.069	0.138	0.026
architecture	0.021	0.051	0.23	0.056	0.032	0.089	0.179	0.099	0.092	0.105	0.034	0.044
interface	0.062	0.016	0.228	0.011	0.075	0.109	0.058	0.02	0.007	0.047	0.031	0.066
networks	0.041	0.183	0.226	0.09	0.112	0.078	0.146	0.147	0.305	0.05	0.136	0.028
project	0.077	0.02	0.226	0.045	0.05	0.061	0.003	0.014	0.054	0.025	0.047	0.04
platform	0.008	0.043	0.225	0.037	0.026	0.011	0.018	0.022	0.017	0.034	0.033	0.055
Evolution	0.006	0.025	0.224	0.045	0.085	0.037	0.017	0.004	0.002	0.015	0.026	0.026
networking	0.017	0.022	0.224	0.032	0.069	0.012	0.033	0.013	0.197	0.012	0.094	0.02
Next	0.02	0.027	0.223	0.066	0.041	0.035	0.007	0.015	0.001	0.013	0.005	0.046
coverage	0.029	0.013	0.223	0.029	0.003	0.003	0.034	0.107	0.036	0.055	0.009	0.06
concepts	0.047	0.031	0.22	0.031	0.031	0.037	0.005	0.043	0.003	0.014	0.007	0.038
flexible	0.008	0.044	0.218	0.014	0.078	0.06	0.041	0.018	0.018	0.009	0.096	0.028
key	0.045	0.02	0.216	0.002	0.026	0.011	0.029	0.007	0.072	0.001	0.027	0.024
challenges	0.012	0.035	0.215	0.03	0.016	0.053	0.081	0.047	0.024	0.038	0.047	0.017
variety	0.015	0.001	0.213	0.016	0.056	0.017	0.005	0.02	0.017	0.012	0	0.018
emerging	0.016	0.025	0.212	0.029	0.046	0.034	0.04	0.043	0.005	0.01	0.015	0.006
air	0.051	0.02	0.212	0.045	0.013	0.036	0.002	0.002	0.011	0.023	0.06	0.034
management	0.019	0.05	0.208	0.062	0.129	0.049	0.274	0.12	0.216	0.042	0.026	0.014
mobility	0.046	0.099	0.207	0.099	0.129	0.096	0.222	0.083	0.35	0.023	0.036	0.021
supporting	0.001	0.025	0.201	0.037	0.036	0.064	0.222	0.096	0.039	0.037	0.039	0.052
architectures	0.066	0.002	0.201	0.019	0.025	0.013	0.051	0.065	0.022	0.024	0.032	0.048
GSM	0.04	0.056	0.2	0.006	0.044	0.037	0.089	0.002	0.021	0.015	0.105	0.076
equalizer	0.103	0.037	0.027	0.409	0.017	0.007	0.018	0.031	0.026	0.043	0.074	0.003
equalization	0.081	0.046	0.007	0.397	0.062	0.02	0.027	0.029	0.017	0.019	0.053	0
multipath	0.079	0.154	0.053	0.365	0.095	0.056	0.017	0.211	0.096	0.123	0.027	0.205
interference	0.029	0.039	0.02	0.363	0.092	0.001	0.012	0.246	0.095	0.116	0.256	0.092
blind	0.067	0.009	0.04	0.331	0.042	0.057	0.034	0.018	0	0.103	0.054	0.034
multiuser	0.05	0.034	0.011	0.325	0.028	0.079	0.083	0.039	0.014	0.023	0.164	0.111
Response	0.014	0.029	0.027	0.322	0.024	0.042	0.008	0.039	0.012	0.071	0.072	0.105
feedback	0.101	0.01	0.036	0.321	0.003	0.032	0.025	0.004	0.025	0.033	0.036	0.015
intersymbol	0.026	0.062	0.015	0.321	0.042	0.004	0.017	0.034	0.042	0.02	0.078	0.103
estimation	0	0.024	0.078	0.315	0.023	0.043	0.027	0.145	0.027	0.05	0.038	0.112
receiver	0.016	0.077	0.076	0.315	0.052	0.097	0.013	0.214	0.036	0.048	0.072	0.143
adaptive	0.064	0.066	0.012	0.313	0.031	0.038	0.124	0.129	0.021	0.076	0.067	0.064
impulse	0.03	0.048	0.014	0.301	0.045	0.043	0.005	0.032	0.062	0.064	0.09	0.029
channels	0.09	0.026	0.058	0.297	0.026	0.058	0.042	0.072	0.064	0.07	0.072	0.218
processing	0.074	0.035	0.037	0.29	0.045	0.138	0.011	0.016	0.009	0.007	0.07	0.086
array	0.103	0.005	0.019	0.285	0.054	0.037	0.081	0.267	0.051	0.076	0.012	0.175
suppression	0.067	0.015	0.027	0.284	0.047	0.015	0.019	0.069	0.004	0.033	0.09	0.022
algorithm	0.039	0.147	0.094	0.283	0.048	0.022	0.124	0.029	0.097	0.013	0.003	0.018
decision	0.02	0.044	0.043	0.278	0.001	0.029	0.012	0.001	0.003	0.006	0.002	0.089

complexity	0.058	0.048	0.006	0.276	0.06	0.039	0.045	0.029	0.05	0.052	0.057	0.087
detector	0.085	0.053	0.021	0.264	0.029	0.02	0.045	0.03	0.019	0.012	0.085	0.115
antenna	0.087	0.059	0.005	0.256	0.111	0.072	0.127	0.367	0.122	0.014	0.088	0.101
signal	0.037	0.032	0.047	0.251	0.005	0.216	0.01	0.234	0.067	0.055	0.115	0.06
symbol	0.03	0.01	0.035	0.249	0.001	0.004	0.005	0.075	0.034	0.115	0.005	0.27
propagation	0.046	0.032	0.016	0.248	0.052	0.001	0.037	0.127	0.053	0.128	0.085	0.014
estimates	0.006	0.012	0.028	0.246	0.011	0.028	0.008	0.007	0.012	0.029	0.034	0.026
symbols	0.012	0.008	0.049	0.239	0.018	0.045	0.048	0.157	0.007	0.066	0.006	0.119
joint	0.048	0.005	0.023	0.236	0.03	0.039	0.015	0.026	0.035	0.04	0.067	0.088
computational	0.014	0.031	0.038	0.235	0.006	0.011	0.005	0.052	0.021	0.025	0.011	0.014
square	0.014	0.002	0.052	0.221	0.024	0.021	0.036	0.069	0.021	0.038	0.065	0.048
desired	0.031	0.036	0.026	0.218	0.008	0.011	0.129	0.187	0	0.03	0.055	0.074
simulations	0.038	0.05	0.044	0.212	0.047	0.056	0.01	0.031	0.031	0.02	0.094	0.109
estimate	0.046	0.066	0.057	0.207	0.008	0.022	0.046	0.009	0.022	0.078	0.057	0.062
minimum	0	0.018	0.083	0.203	0	0.063	0.056	0.094	0.024	0.017	0.013	0.012
signals	0.014	0.047	0.038	0.2	0.011	0.123	0.054	0.066	0.068	0.061	0.167	0.07
diversity	0.006	0.12	0.008	0.2	0.109	0.044	0.075	0.382	0.071	0.102	0.015	0.246
rights	0.018	0.067	0.083	0.022	0.848	0.05	0.046	0.041	0.217	0.019	0.028	0.05
B.V	0.022	0.073	0.08	0.02	0.83	0.053	0.056	0.047	0.222	0.017	0.032	0.056
reserved	0.013	0.104	0.072	0.032	0.817	0.052	0.059	0.057	0.213	0.006	0.014	0.044
C	0.002	0.057	0.023	0.029	0.718	0.026	0.051	0.057	0.202	0.047	0.064	0.053
hosts	0.037	0.062	0.01	0.051	0.203	0.033	0.003	0	0.345	0.005	0.021	0.017
CMOS	0.049	0.033	0.06	0.031	0.013	0.484	0	0.035	0.017	0.069	0.015	0.066
supply	0.079	0.039	0.104	0.103	0.018	0.477	0.012	0.037	0.01	0.082	0.001	0.039
GHz	0.026	0.021	0.053	0.044	0.053	0.464	0.035	0.026	0.099	0.022	0.182	0.015
V	0.054	0.061	0.068	0.081	0.022	0.424	0.04	0.042	0.011	0.059	0.01	0.047
circuit	0.028	0.028	0.022	0.009	0.008	0.422	0.07	0.07	0.02	0.03	0.024	0.003
amplifier	0.046	0.061	0.061	0.088	0.015	0.415	0.04	0.029	0.015	0	0.069	0.04
chip	0.06	0.041	0.007	0.063	0.006	0.385	0.027	0.051	0.042	0.055	0.044	0.13
power	0.055	0.101	0.021	0.006	0.06	0.374	0.048	0.339	0.025	0.16	0.187	0.041
RF	0.024	0.059	0.068	0.037	0.044	0.356	0.093	0.019	0.011	0.003	0.022	0.044
MHz	0.044	0.052	0.024	0.038	0.026	0.345	0.008	0.012	0.045	0.026	0.025	0.11
transceiver	0.018	0.031	0	0.061	0.012	0.34	0.01	0.058	0.029	0.091	0.013	0.031
dB	0.021	0.066	0.111	0.051	0.054	0.325	0.085	0.232	0.054	0.005	0.066	0.16
band	0.014	0.009	0.051	0.023	0.065	0.321	0.013	0.02	0.107	0.047	0.073	0.01
2.4	0.035	0.006	0.001	0.008	0.023	0.309	0.001	0.016	0.062	0.043	0.138	0.018
input	0.052	0.004	0.071	0.058	0.008	0.309	0.014	0.005	0.016	0.032	0.037	0.001
digital	0.034	0.055	0.183	0.061	0.044	0.299	0.09	0.051	0.051	0.015	0.105	0.007
frequency	0.042	0.019	0.004	0.117	0.088	0.296	0.061	0.128	0.081	0.036	0.038	0.296
circuits	0.018	0.046	0.021	0.005	0.005	0.295	0.003	0.049	0.008	0.033	0.007	0.018
amplifiers	0.039	0.061	0.027	0.062	0.037	0.284	0.074	0.003	0.014	0.022	0.058	0.003
consumption	0.099	0.021	0.023	0.006	0.018	0.281	0.04	0.007	0.111	0.01	0.041	0.052
output	0.009	0.025	0.091	0.043	0	0.279	0.001	0.017	0.033	0.044	0.06	0.112
M	0.027	0.036	0.064	0.022	0.013	0.273	0.01	0.095	0.01	0.01	0.005	0.066
noise	0.024	0.075	0.097	0.068	0.038	0.267	0.035	0.253	0.037	0.016	0.006	0.157
integrated	0.021	0.157	0.103	0.084	0.042	0.256	0.104	0.123	0.023	0.029	0.027	0.01
filters	0.024	0.039	0.036	0.127	0.006	0.247	0.026	0.021	0.041	0.03	0.019	0.014
offset	0.012	0.014	0.09	0.009	0.007	0.245	0.033	0.04	0.002	0.091	0.007	0.271
range	0.052	0.038	0.037	0.03	0.032	0.238	0.006	0.032	0.002	0.068	0.075	0.026
gain	0.011	0.045	0.055	0.073	0.048	0.229	0.028	0.04	0.061	0.125	0.116	0.075
components	0.019	0.051	0.105	0.047	0.009	0.211	0.004	0.016	0.022	0.029	0.057	0.001
operating	0.005	0.005	0.042	0.012	0.003	0.208	0.033	0.001	0.052	0.065	0.011	0.036
quadrature	0.03	0.043	0.032	0.046	0.017	0.205	0.007	0.028	0.026	0.011	0.006	0.281
low	0.151	0.055	0.056	0.003	0.003	0.205	0.023	0.037	0.053	0.018	0.004	0.053
design	0.032	0.024	0.163	0.037	0.074	0.202	0.044	0.028	0.001	0.048	0.108	0.028
phase	0.016	0.039	0.065	0.008	0.021	0.201	0.03	0.02	0.023	0.019	0.014	0.324
implemented	0.028	0.013	0.015	0.049	0.042	0.2	0.04	0.032	0.002	0.058	0.04	0.027
modem	0.032	0.024	0.037	0.013	0.019	0.2	0.008	0.004	0.034	0.046	0.014	0.022
Call	0.031	0.02	0.002	0.075	0.061	0.02	0.409	0.163	0.036	0.09	0.116	0.018
QoS	0.112	0.114	0.152	0.075	0.008	0.073	0.408	0.154	0.057	0.003	0.005	0.015
handoff	0.039	0.064	0.041	0.068	0.058	0.026	0.405	0.164	0.059	0.028	0.107	0.004
admission	0.025	0.088	0.019	0.03	0.093	0.006	0.369	0.16	0.039	0.1	0.097	0.016
blocking	0.057	0.061	0.05	0.055	0.073	0.034	0.303	0.146	0.051	0.133	0.124	0.001
calls	0.046	0.033	0.056	0.044	0.051	0.028	0.288	0.153	0.036	0.078	0.087	0.002
connections	0.052	0.015	0.016	0.031	0.091	0.038	0.28	0.131	0.078	0.014	0.017	0.056
quality	0.167	0.081	0.174	0.034	0.001	0.038	0.28	0.097	0.048	0.01	0.077	0.062
resource	0.006	0.1	0.08	0.049	0.03	0.029	0.278	0.137	0.066	0.005	0.109	0.002
connection	0.104	0.035	0.045	0.021	0.07	0.005	0.272	0.122	0.106	0.013	0.011	0.073
guarantee	0.05	0.058	0.036	0.029	0.095	0.003	0.256	0.085	0.015	0.047	0.021	0.007
Asynchronous	0.158	0.055	0.043	0.087	0.083	0.06	0.255	0.059	0.075	0.069	0.049	0.102
signaling	0.023	0.058	0.13	0	0.033	0.027	0.25	0.111	0.1	0.018	0.034	0.103
switch	0.012	0.039	0.012	0.009	0.115	0.101	0.245	0.089	0.055	0.004	0.029	0.055
mode	0.181	0.06	0.03	0.039	0.053	0.045	0.242	0.12	0.058	0.122	0.022	0.063
cell	0.147	0.014	0.03	0.013	0.038	0.038	0.236	0.052	0.075	0.102	0.191	0.125

virtual	0.033	0.022	0.018	0.019	0.091	0.004	0.236	0.087	0.108	0.046	0.001	0.015
path	0.004	0.098	0.046	0.013	0.05	0.005	0.23	0.202	0.082	0.151	0.012	0.035
bandwidth	0.063	0.117	0.043	0.057	0.018	0.092	0.22	0.081	0.094	0.023	0.008	0.105
Handover	0.008	0.022	0.109	0.043	0.023	0.06	0.206	0.027	0.026	0.005	0.018	0.052
fixed	0.02	0.021	0.103	0.022	0.003	0.01	0.205	0.052	0.101	0.063	0.016	0.024
cells	0.114	0.014	0.01	0.041	0.085	0.02	0.204	0.065	0.063	0.099	0.14	0.086
resources	0.015	0.073	0.07	0.019	0.048	0.002	0.202	0.101	0.104	0.02	0.075	0.041
dynamic	0.004	0.176	0.003	0.029	0.024	0.008	0.2	0.082	0.204	0.025	0.075	0.006
Rake	0.008	0.09	0.041	0.09	0.022	0.046	0.107	0.512	0.067	0.017	0.076	0.117
coherent	0.007	0.074	0.04	0.036	0.004	0.018	0.142	0.505	0.06	0.057	0.031	0.216
pilot	0.002	0.019	0.055	0.071	0.02	0.054	0.151	0.454	0.027	0.132	0.041	0.089
background	0.009	0.023	0.007	0.053	0.023	0.005	0.169	0.437	0.04	0.016	0.026	0.014
W-CDMA	0.037	0.029	0.035	0.014	0.033	0.04	0.172	0.428	0.049	0.135	0.063	0.015
reverse	0.047	0.057	0.039	0.016	0.028	0.016	0.131	0.423	0.044	0.026	0.16	0.077
laboratory	0.043	0.002	0.004	0.027	0.015	0.039	0.148	0.414	0.03	0.084	0.084	0.014
SIR	0.001	0.004	0.04	0.039	0.046	0.006	0.165	0.388	0.005	0.033	0.025	0.078
DS-CDMA	0.034	0.063	0.053	0.028	0.012	0.091	0.091	0.384	0.074	0.028	0.194	0.11
ratio	0.057	0.06	0.081	0.117	0.042	0.072	0.137	0.379	0.037	0.121	0.053	0.066
signal-to-interferenc	0.005	0.03	0.038	0.032	0.024	0.022	0.171	0.358	0.018	0.003	0.065	0.122
combining	0.083	0.086	0.042	0.044	0.036	0.027	0.084	0.352	0.032	0.047	0.043	0.202
field	0.068	0.003	0.056	0.026	0.009	0.045	0.124	0.317	0.043	0.064	0.07	0.023
average	0.052	0.106	0.119	0.03	0.069	0.034	0.126	0.287	0.017	0.197	0.022	0.081
paths	0.028	0.099	0.059	0.024	0.055	0.01	0.108	0.278	0.106	0.069	0.024	0.073
reception	0.031	0.024	0.008	0.095	0.002	0.002	0.047	0.276	0.01	0.028	0.002	0.043
wideband	0.096	0.003	0.112	0.019	0.075	0	0.092	0.273	0.091	0.078	0.07	0.011
direct	0.074	0.011	0.024	0.001	0.056	0.002	0.035	0.272	0.084	0.081	0.169	0.224
sequence	0.059	0.012	0.007	0.044	0.056	0.037	0.051	0.264	0.092	0.022	0.151	0.239
achievable	0.045	0.017	0.005	0.028	0.004	0.006	0.043	0.262	0.015	0.031	0.013	0.021
density	0.039	0.037	0.036	0.065	0.012	0.07	0.077	0.258	0.021	0.07	0.056	0.03
experiments	0.06	0.021	0	0.037	0.048	0.028	0.179	0.256	0.073	0.042	0.116	0.06
fast	0.055	0.012	0.013	0.12	0.012	0.008	0.158	0.255	0.086	0.084	0.02	0.046
Doppler	0.066	0.029	0.038	0.027	0.018	0	0.02	0.241	0.009	0.027	0.016	0.201
Rayleigh	0.173	0.11	0.098	0.041	0.064	0.102	0.048	0.23	0.063	0.18	0.04	0.207
energy	0.085	0.001	0.061	0.023	0.012	0.089	0.022	0.218	0.099	0.022	0.033	0.023
experimental	0.041	0.005	0.005	0.065	0.008	0.074	0.156	0.206	0.008	0.071	0.119	0.027
received	0.094	0	0.06	0.134	0.012	0.07	0.024	0.206	0.001	0.133	0.086	0.02
measurement	0.022	0	0.012	0.023	0.012	0.045	0.122	0.2	0.057	0.002	0.063	0.031
hoc	0.106	0.02	0.03	0.076	0.166	0.07	0.063	0.043	0.594	0.019	0.045	0.018
routing	0.066	0.056	0.041	0.067	0.198	0.058	0.025	0.01	0.592	0.027	0.003	0.013
ad	0.107	0.019	0.03	0.071	0.157	0.063	0.063	0.044	0.591	0.025	0.042	0.013
nodes	0.079	0.063	0.057	0.044	0.155	0.017	0.02	0.016	0.457	0.002	0.048	0.009
route	0.008	0.059	0.075	0.043	0.093	0.003	0.028	0.012	0.431	0.017	0.021	0.004
node	0.027	0.037	0.038	0.015	0.125	0.006	0.028	0.007	0.367	0.001	0.03	0.021
topology	0.032	0.035	0.017	0.019	0.118	0.01	0.008	0.01	0.353	0.036	0.039	0.003
location	0.039	0.09	0.051	0.039	0.092	0.03	0.108	0.025	0.3	0.004	0.03	0.003
host	0.047	0.042	0.038	0.031	0.126	0.022	0.025	0.01	0.283	0.025	0.025	0.03
protocols	0.083	0.19	0.092	0.071	0.142	0.1	0.06	0.04	0.277	0.026	0.101	0.076
multicast	0.084	0.044	0.02	0.019	0.175	0.058	0.065	0.041	0.259	0.031	0.026	0.016
overhead	0.055	0.108	0.026	0.049	0.025	0.004	0.038	0.018	0.258	0.082	0.021	0.008
messages	0.041	0.132	0.047	0.027	0.036	0.013	0.001	0.001	0.234	0.034	0.017	0.049
connectivity	0.011	0.001	0.137	0.035	0.033	0.009	0.05	0.004	0.223	0.012	0.062	0.038
distributed	0.052	0.149	0.001	0.016	0.134	0.014	0.04	0.021	0.215	0.115	0.007	0.041
wired	0.017	0.022	0.165	0.048	0.106	0.013	0.078	0.029	0.209	0.015	0.076	0.017
source	0.051	0.054	0.033	0.052	0.072	0.018	0.125	0.028	0.205	0.045	0.028	0.008
probability	0.004	0.078	0.156	0.087	0.071	0.084	0.118	0.005	0.033	0.36	0.116	0.1
model	0.036	0.07	0.057	0.011	0.03	0.05	0.024	0.023	0.001	0.347	0.004	0.04
distribution	0.01	0.028	0.016	0.002	0.053	0.014	0.078	0.032	0.004	0.25	0.031	0.071
derived	0.031	0.022	0.05	0.079	0.002	0.035	0.021	0.006	0.041	0.246	0.106	0.091
probabilities	0.021	0.038	0.055	0.017	0.055	0.05	0.148	0.056	0.008	0.246	0.04	0.027
parameters	0.087	0.03	0.037	0.052	0.039	0.007	0.056	0.042	0.004	0.244	0.002	0.028
derive	0.016	0.095	0.055	0.005	0.027	0.029	0.02	0.007	0.012	0.239	0	0.078
models	0.03	0.017	0.018	0.009	0.055	0.041	0.054	0.01	0.025	0.238	0.08	0.014
analyze	0.017	0.118	0.041	0.032	0.066	0.035	0.007	0.032	0.02	0.227	0.007	0.039
analytical	0.028	0.05	0.061	0.01	0.051	0.098	0.015	0.064	0.012	0.225	0.014	0.056
outage	0.024	0.104	0.048	0.004	0.065	0.02	0.038	0.044	0.056	0.222	0.067	0.021
approximation	0.027	0.031	0.062	0.016	0.012	0.054	0.013	0.009	0.052	0.222	0.056	0.033
expressions	0.014	0.038	0.035	0.034	0.017	0.049	0.026	0.039	0.019	0.222	0.031	0.114
account	0.001	0.005	0.031	0.007	0.048	0.058	0.028	0.02	0.036	0.217	0.044	0.001
shadowing	0.115	0.041	0.029	0.041	0.014	0.04	0.024	0.097	0.075	0.214	0.053	0.001
particular	0.017	0.007	0.121	0	0.026	0.031	0.029	0.024	0.062	0.213	0.008	0.032

capture	0.033	0.108	0.019	0.037	0.063	0.066	0.009	0.052	0.017	0.213	0.043	0.028
case	0.004	0.068	0.011	0.103	0.036	0.005	0.004	0.057	0.035	0.212	0.063	0.083
number	0.046	0.123	0.03	0.042	0.021	0.005	0.074	0.146	0.069	0.208	0.117	0.04
function	0.004	0.004	0.022	0.005	0.063	0.059	0.039	0.012	0.004	0.207	0.009	0.004
system	0.042	0.044	0.145	0.068	0.044	0.033	0.008	0.014	0.107	0.206	0.286	0.059
random	0.002	0.15	0.049	0.024	0.049	0.041	0.027	0.002	0.02	0.201	0.099	0.011
terms	0.064	0.078	0.048	0.059	0.034	0.023	0.082	0.001	0.012	0.201	0.095	0.038
CDMA	0.075	0.026	0.049	0.15	0.096	0.079	0.082	0.02	0.145	0.109	0.551	0.01
code	0.025	0.044	0.011	0.114	0.008	0.006	0.005	0.171	0.14	0.016	0.44	0.238
division	0.05	0.099	0.036	0.128	0.003	0.001	0.004	0.145	0.144	0.002	0.425	0.215
capacity	0.064	0.062	0.062	0.037	0.096	0.034	0.056	0.142	0.119	0.178	0.41	0.108
code-division	0.042	0.07	0.006	0.134	0.056	0.002	0.102	0.006	0.064	0.152	0.333	0.061
cellular	0.041	0.057	0.176	0.03	0.098	0.019	0.002	0.006	0	0.126	0.331	0.115
multiple-access	0.033	0.035	0.007	0.162	0.044	0.019	0.08	0.013	0.07	0.162	0.32	0.03
base	0.036	0.154	0.027	0.075	0.022	0.022	0.088	0.136	0.03	0.075	0.314	0.238
users	0.038	0.072	0.181	0.104	0.042	0.052	0.11	0.134	0.014	0.069	0.278	0.038
uplink	0.029	0.173	0.015	0.169	0.045	0.054	0.026	0.015	0.069	0.005	0.253	0.063
area	0.062	0.178	0.151	0.063	0.085	0.098	0.094	0.058	0.045	0.103	0.241	0.011
indoor	0.025	0.053	0.051	0.168	0.106	0.033	0.043	0.039	0.141	0.097	0.237	0.149
LAN	0.047	0.104	0.036	0.019	0.037	0.137	0.051	0.014	0.045	0.013	0.233	0.044
direct-sequence	0.014	0.074	0.013	0.112	0.014	0.032	0.075	0.024	0.061	0.147	0.232	0.115
spreading	0.003	0.087	0.006	0.142	0.006	0.027	0.01	0.162	0.054	0.074	0.223	0.224
user	0.02	0.036	0.13	0.12	0.034	0.035	0.117	0.049	0.016	0.055	0.215	0.018
WLAN	0.051	0.083	0.09	0.01	0.012	0.083	0.039	0.001	0.063	0.006	0.215	0.05
codes	0.095	0.084	0.035	0.083	0.03	0.055	0.045	0.056	0.062	0.068	0.211	0.276
keying	0.023	0.099	0.026	0.029	0.023	0.077	0.023	0.014	0.046	0.143	0.07	0.496
modulation	0.067	0.086	0.009	0.056	0.052	0.149	0.082	0.007	0.074	0.043	0.01	0.471
shift	0.019	0.085	0.017	0.022	0.018	0.079	0.048	0.025	0.02	0.129	0.039	0.432
differential	0.034	0.055	0.05	0.017	0.005	0.068	0.015	0.036	0.008	0.049	0.018	0.412
orthogonal	0.018	0.009	0.03	0.163	0.023	0.016	0.031	0.103	0.055	0.1	0.104	0.337
QPSK	0.071	0.052	0.014	0.025	0.007	0.09	0.004	0.026	0.046	0.002	0.012	0.29
OFDM	0.034	0.009	0.039	0.152	0.047	0.017	0.043	0.038	0.037	0.131	0.03	0.245
spread	0.029	0.036	0.026	0.101	0.03	0.095	0.042	0.079	0.098	0.102	0.062	0.231
detection	0.087	0.11	0.04	0.167	0.027	0.05	0.135	0.099	0.043	0.08	0.085	0.223
scheme	0.174	0.179	0.13	0.045	0.013	0.08	0.18	0.004	0.099	0.025	0.166	0.221
Gaussian	0.075	0.085	0.023	0.091	0.032	0.02	0.091	0.037	0.039	0.135	0.059	0.22
multiplexing	0.036	0.111	0.011	0.095	0.02	0.013	0.068	0.033	0.055	0.077	0.02	0.216
binary	0.017	0.058	0.016	0.006	0.005	0.011	0.011	0.059	0.022	0.169	0.011	0.201
schemes	0.063	0.105	0	0.033	0.005	0.054	0.069	0.028	0.125	0.098	0.109	0.195
carrier	0.078	0.185	0.051	0.011	0.019	0.145	0.108	0.054	0.018	0.019	0.026	0.19
timing	0.007	0.055	0.061	0.159	0.049	0.027	0.017	0.082	0.022	0.085	0.022	0.163
spread-spectrum	0.041	0.069	0.02	0.056	0.01	0.077	0.085	0.033	0.027	0.076	0.027	0.153
technique	0.047	0.053	0.007	0.162	0.026	0.022	0.015	0.043	0.107	0.037	0.114	0.146
spectrum	0.005	0.022	0.147	0.02	0.035	0.111	0.023	0.153	0.1	0.062	0.046	0.146
synchronization	0.032	0.024	0.022	0.037	0.019	0.054	0.018	0.019	0.014	0.014	0.057	0.144
smart	0.043	0.02	0.14	0.122	0.045	0.044	0.012	0.055	0.023	0.009	0.002	0.142
parallel	0.006	0.003	0.017	0.117	0.011	0.04	0.037	0.076	0.001	0.012	0.074	0.14
multicarrier	0.012	0.012	0.005	0.137	0.032	0.012	0.078	0.002	0.006	0.052	0.105	0.132
selection	0.003	0.052	0.027	0.011	0.007	0.001	0.049	0.096	0.023	0.1	0.026	0.128
decoding	0.087	0.024	0.052	0.106	0.016	0.006	0.012	0.086	0.022	0.066	0.099	0.127
combined	0.019	0.003	0.02	0.111	0.011	0.021	0.056	0.142	0.014	0.039	0.026	0.125
suited	0.017	0.056	0.09	0.059	0.034	0.054	0.003	0.067	0.051	0.007	0.052	0.121
nonlinear	0.011	0.046	0.016	0.115	0.017	0.085	0.041	0.039	0.034	0.069	0.085	0.12
satellite	0.005	0.045	0.096	0.085	0.001	0.003	0.059	0.022	0.014	0.111	0.11	0.119
sequences	0.021	0.006	0.024	0.171	0.003	0.043	0.008	0.003	0.01	0.066	0.086	0.118
computers	0.072	0.047	0.136	0.01	0.066	0.052	0.086	0.004	0.093	0.022	0.047	0.118
filter	0	0.063	0.066	0.174	0.009	0.162	0.023	0.125	0.016	0.036	0.031	0.116
equal	0.093	0.018	0.059	0.002	0.039	0.013	0.009	0.138	0.01	0.124	0.035	0.114
robust	0.042	0.041	0.006	0.16	0.014	0.009	0.018	0.022	0.046	0.01	0.065	0.113
achieve	0.151	0.061	0.016	0.053	0.009	0.054	0.026	0.046	0.002	0.013	0.031	0.109
devices	0.063	0.07	0.147	0.034	0.059	0.16	0.147	0	0.074	0.046	0.054	0.107
solution	0.01	0.028	0.084	0.037	0.093	0.05	0	0.075	0.012	0.016	0.031	0.105
constant	0.037	0.038	0.046	0.014	0.023	0.064	0.084	0.035	0.004	0.069	0.006	0.105
mobiles	0.006	0.025	0.005	0.002	0.009	0.02	0.064	0.015	0.034	0.143	0.131	0.104
recovery	0.144	0.014	0.033	0.079	0.058	0.052	0.001	0.012	0.12	0.045	0.034	0.104
stations	0.059	0.193	0.037	0.037	0.069	0.015	0.044	0.065	0.038	0.044	0.069	0.103
employs	0.072	0.068	0.008	0.051	0.021	0.035	0.039	0.049	0.006	0.013	0.031	0.102
computer	0.061	0.069	0.033	0.098	0.004	0.04	0.022	0.181	0.052	0.098	0.106	0.101
transmitted	0.154	0.153	0.05	0.052	0.009	0.057	0.025	0.095	0	0.024	0.06	0.101
hybrid	0.189	0.096	0.007	0.052	0.007	0.042	0.045	0.013	0.046	0.008	0.005	0.099

n	0.007	0.003	0.059	0.017	0.001	0.044	0.025	0.04	0.057	0.046	0	0.098
computing	0.022	0.044	0.109	0.025	0.055	0.001	0.069	0.001	0.125	0.002	0.017	0.096
reduced	0.046	0.018	0.055	0.062	0.005	0.075	0.073	0.046	0.049	0.017	0.088	0.091
Bluetooth	0.022	0.066	0.046	0.056	0.039	0.103	0.126	0.012	0.014	0.064	0.075	0.09
arrival	0.086	0.02	0.05	0.136	0.017	0.048	0.094	0.056	0.006	0.107	0.028	0.09
TCP/IP	0.107	0.022	0.095	0.024	0.035	0.013	0.011	0.024	0.055	0.017	0.074	0.085
block	0.081	0.025	0.039	0.105	0.025	0	0.013	0.017	0.023	0.045	0.002	0.085
variable	0.114	0.118	0.011	0.022	0.026	0.1	0.164	0.074	0.061	0.026	0.094	0.084
vector	0.068	0.004	0.05	0.158	0.014	0.06	0.029	0.017	0.054	0.032	0.023	0.084
phone	0.026	0.033	0.095	0.056	0.038	0.096	0.069	0.006	0.019	0.021	0.161	0.082
size	0.113	0.026	0.059	0.052	0.065	0.1	0.033	0.097	0.019	0.054	0.049	0.082
portable	0.11	0.03	0.137	0.025	0.001	0.121	0.078	0.007	0.071	0.01	0.019	0.082
equipment	0.085	0.008	0.085	0.03	0.015	0.056	0.053	0.003	0.033	0.066	0.01	0.082
measurements	0.014	0.052	0	0.052	0.058	0.085	0.016	0.063	0.029	0.074	0.156	0.081
highly	0.043	0.015	0.078	0.022	0.023	0.047	0.032	0.055	0.097	0.041	0.008	0.078
spectral	0.059	0.052	0.047	0.044	0.073	0.049	0.03	0.035	0.015	0.015	0.113	0.076
wave	0.012	0.056	0.01	0.043	0.035	0.132	0.008	0.01	0.062	0.008	0.099	0.076
proposes	0.094	0.088	0.066	0.019	0.028	0.027	0.101	0.073	0.028	0.091	0.073	0.076
software	0.045	0.021	0.195	0.01	0.114	0.031	0.006	0.015	0.007	0.044	0.039	0.075
techniques	0.011	0.017	0.131	0.182	0.001	0.023	0.017	0.06	0.015	0.099	0.114	0.074
small	0.025	0.062	0.004	0.042	0.03	0.058	0.006	0.106	0.053	0.029	0.005	0.074
receivers	0.012	0.065	0.006	0.168	0.028	0.014	0.039	0.022	0.028	0.087	0.082	0.073
combination	0	0.034	0.049	0.014	0.037	0.003	0.009	0.077	0.028	0.035	0.039	0.073
attractive	0.006	0.027	0.115	0.046	0.035	0.021	0.011	0.02	0.025	0.014	0.032	0.073
mechanisms	0.08	0.012	0.065	0.023	0.053	0.024	0.067	0.029	0.141	0.018	0.024	0.073
offers	0.034	0.103	0.077	0.012	0.065	0.003	0.044	0.042	0.031	0.031	0.002	0.072
conventional	0.07	0.012	0.085	0.144	0.002	0.024	0.044	0.024	0.038	0.018	0.177	0.071
inherent	0.025	0.011	0.045	0.095	0.041	0.004	0	0.007	0.028	0.085	0.071	0.071
delays	0.045	0.113	0.053	0.08	0.002	0.041	0.014	0.02	0.073	0.034	0.05	0.071
theoretical	0.035	0.046	0.046	0.105	0.017	0.015	0.066	0.028	0.009	0.061	0.012	0.071
full	0.047	0.042	0.125	0.019	0.023	0.064	0.02	0.006	0.02	0.048	0.008	0.071
application	0.107	0.044	0.148	0.022	0.001	0.055	0.003	0.027	0.015	0.004	0.004	0.071
DS/CDMA	0.007	0.028	0.045	0.071	0.068	0.045	0.013	0.053	0.059	0.079	0.151	0.07
correlation	0.009	0.039	0.052	0.095	0.032	0.008	0.001	0.062	0.045	0.134	0.054	0.07
method	0.029	0.058	0.121	0.157	0.005	0.011	0.003	0.014	0.1	0.061	0.041	0.07
increase	0.02	0.024	0.003	0.09	0.027	0.004	0.028	0.093	0.051	0.05	0.119	0.069
minimize	0.09	0.001	0.011	0.015	0.017	0.084	0.032	0.033	0.091	0.006	0.052	0.069
spatial	0.052	0.035	0.027	0.177	0.066	0.037	0.019	0.037	0.019	0.085	0.022	0.069
elements	0.018	0.042	0.044	0.093	0.029	0.044	0.02	0.019	0.003	0.014	0.004	0.069
three	0.016	0.038	0.002	0.047	0.057	0.018	0.092	0.038	0.011	0.108	0.065	0.068
areas	0.01	0.043	0.161	0.017	0.004	0.012	0.026	0.044	0.043	0.021	0.046	0.068
cancellation	0.043	0.029	0.032	0.182	0.002	0.068	0.037	0.079	0.044	0.008	0.151	0.066
cost	0.012	0.002	0.112	0.04	0.084	0.119	0.003	0.059	0.034	0.012	0.053	0.066
paper	0.168	0.191	0.09	0.105	0.174	0.053	0.12	0.062	0.058	0.147	0.119	0.065
pattern	0.031	0.012	0.036	0.069	0.02	0.039	0.022	0.003	0.021	0.012	0.038	0.065
environment	0.032	0.021	0.117	0.033	0.019	0.039	0.049	0.064	0.063	0.169	0.043	0.064
efficient	0.048	0.109	0.006	0.037	0.056	0.032	0.099	0.095	0.162	0.018	0.056	0.063
essential	0.002	0.008	0.054	0.001	0.064	0.02	0.037	0.036	0.004	0.07	0.053	0.063
potential	0.012	0	0.177	0.065	0.038	0.008	0.048	0.045	0.029	0.032	0.032	0.063
antennas	0.032	0.05	0.037	0.178	0.116	0.07	0.049	0.192	0.059	0.063	0.086	0.062
combines	0.003	0.046	0.042	0.022	0.003	0.016	0.011	0.001	0.004	0.011	0.019	0.062
efficiency	0.108	0.097	0.026	0.061	0.029	0.093	0.044	0.033	0.029	0.023	0.094	0.061
activity	0.027	0.034	0.063	0.017	0.025	0.013	0.001	0.006	0.012	0.139	0.089	0.061
central	0.041	0.098	0.004	0.037	0.038	0.022	0.02	0.039	0.018	0.013	0.031	0.061
investigates	0.014	0.039	0.023	0.005	0.03	0.031	0.094	0.098	0.061	0.042	0.021	0.061
advantage	0.022	0.008	0.015	0.05	0.024	0.068	0.009	0.015	0.062	0.031	0.008	0.061
streams	0.127	0.114	0.013	0.078	0.001	0.001	0.105	0.062	0.031	0.024	0.008	0.061
domain	0.039	0.034	0.096	0.035	0.005	0.031	0.009	0.004	0.001	0.019	0.006	0.06
degradation	0.166	0.012	0.069	0.088	0.03	0.056	0.014	0.029	0.002	0.002	0.041	0.059
behavior	0.004	0.052	0.018	0.033	0.025	0.001	0.008	0.022	0.095	0.151	0.04	0.059
unique	0.016	0.008	0.12	0.019	0.011	0.016	0.053	0.005	0.072	0.001	0.011	0.059
synchronous	0.01	0.06	0.008	0.102	0.04	0.009	0.052	0.006	0.036	0.014	0.071	0.058
performances	0.011	0.076	0.036	0.006	0.004	0.033	0.015	0.013	0.009	0.012	0.049	0.058
larger	0.07	0.014	0.012	0.059	0.002	0.015	0.017	0.04	0.017	0.077	0.034	0.058
algorithms	0.048	0.064	0.006	0.177	0.012	0.002	0.09	0.009	0.156	0.055	0.033	0.058
complex	0.012	0.032	0.012	0.177	0.016	0.043	0.006	0.003	0.001	0.104	0.027	0.058
linear	0.037	0.014	0.008	0.15	0.025	0.04	0.007	0.045	0.017	0.054	0.071	0.057
needs	0.028	0.001	0.12	0.025	0.035	0.002	0.031	0.005	0.056	0.017	0.041	0.057
device	0.072	0.048	0.132	0.045	0.079	0.153	0.085	0.02	0.011	0.003	0.032	0.057
and/or	0.061	0.025	0.018	0.028	0.006	0.008	0.068	0.017	0.063	0.053	0.017	0.057

patterns	0.008	0.02	0.015	0.055	0.004	0.031	0.004	0.013	0.001	0.052	0.069	0.056
sufficient	0.096	0.005	0.039	0.074	0.016	0.096	0.026	0.032	0.004	0	0.045	0.056
statistics	0.025	0.037	0.021	0.101	0.045	0.041	0.01	0.007	0.021	0.122	0.029	0.056
lead	0.048	0.008	0.074	0.053	0.027	0.013	0.01	0.022	0.05	0.045	0.023	0.056
end	0.03	0.005	0.098	0.032	0.003	0.016	0.035	0.059	0.002	0.019	0.008	0.056
achieves	0.059	0.032	0.067	0.064	0.018	0.17	0.002	0.025	0.046	0.08	0.005	0.056
environments	0.032	0.02	0.091	0.104	0.024	0.065	0.089	0.094	0.056	0.004	0.047	0.055
hand	0.1	0.119	0.07	0.007	0.003	0.024	0.002	0.025	0.003	0.064	0.083	0.054
specification	0.032	0.023	0.105	0.039	0.001	0.011	0.026	0.021	0.006	0.007	0.083	0.054
four	0.017	0.011	0.006	0.075	0.006	0.057	0.104	0.081	0.059	0.035	0.034	0.054
additional	0.024	0.036	0.033	0.078	0.024	0.023	0.009	0.002	0.061	0.025	0.068	0.053
procedure	0.011	0.084	0.037	0.072	0.081	0.011	0.034	0.037	0.013	0.064	0.028	0.053
receive	0.018	0.026	0.051	0.014	0.011	0.137	0.014	0.044	0.045	0.051	0.009	0.053
Ethernet	0.018	0.117	0.03	0.026	0.019	0.002	0.071	0.001	0.032	0.024	0.158	0.052
comparison	0.06	0.033	0.002	0.045	0.028	0.045	0.011	0.007	0.004	0.121	0.053	0.052
find	0.019	0.008	0.016	0.005	0.05	0.022	0.005	0.019	0.089	0.161	0.026	0.052
long	0.055	0.06	0.003	0.04	0.006	0.043	0.012	0.001	0.068	0.046	0.026	0.052
attention	0.043	0.015	0.141	0.012	0.013	0.024	0.006	0.005	0.026	0.051	0.052	0.051
nature	0.001	0.004	0.079	0.012	0.009	0.009	0.011	0.008	0.11	0.081	0.03	0.051
sensitive	0.09	0.04	0.005	0.053	0.007	0.007	0.002	0.026	0.011	0.009	0.01	0.051
high-speed	0.066	0.059	0.116	0.035	0.042	0.064	0.043	0.007	0.073	0.087	0.091	0.05
levels	0.037	0.042	0.024	0.012	0.073	0.053	0.123	0.019	0.039	0.124	0.085	0.05
large	0.045	0.093	0.031	0.034	0.031	0.104	0.05	0.123	0.047	0.073	0.069	0.05
addressed	0.026	0.001	0.14	0	0.009	0.004	0.007	0.008	0.082	0.025	0.003	0.05
makes	0.007	0.005	0.014	0.008	0.036	0.008	0.021	0.027	0.121	0.009	0	0.05
mean	0.008	0.041	0.08	0.193	0.025	0.042	0.037	0.102	0.008	0.131	0.042	0.049
I	0.038	0.002	0.006	0.011	0.014	0.067	0.011	0.028	0.027	0.042	0.04	0.049
parameter	0.062	0.009	0.06	0.013	0.007	0.03	0.015	0.025	0.014	0.123	0.014	0.049
handle	0.074	0.068	0.035	0.022	0.029	0.008	0.06	0.059	0.068	0.007	0.074	0.048
increasing	0.057	0.028	0.073	0.05	0.005	0.026	0.036	0.1	0.016	0.024	0.066	0.048
fact	0.017	0.04	0.033	0.055	0.009	0.017	0.001	0.018	0.016	0.062	0.059	0.048
employed	0.058	0.042	0.008	0.017	0.01	0.057	0.025	0.039	0.079	0.125	0.032	0.048
mechanism	0.116	0.126	0.003	0.027	0.071	0.045	0.043	0.029	0.139	0.026	0.018	0.048
directly	0.019	0.007	0.014	0.052	0.017	0.037	0.021	0.005	0.129	0.02	0.008	0.048
existing	0.005	0.035	0.133	0.076	0.102	0.057	0.039	0.054	0.151	0.035	0.001	0.048
layers	0.14	0.038	0.152	0.038	0.007	0.047	0.029	0.029	0.004	0.023	0.13	0.047
increased	0.006	0.048	0.004	0.039	0.01	0.011	0.012	0.125	0.045	0.004	0.062	0.047
enables	0.041	0.036	0.036	0.034	0.009	0.082	0.001	0.031	0.099	0.053	0.04	0.047
simulated	0.012	0.004	0.03	0.014	0.047	0.017	0.008	0.045	0.015	0.074	0.022	0.047
introduced	0.017	0.014	0.028	0.05	0.036	0.023	0.009	0.008	0.058	0.069	0.017	0.047
transmitter	0.02	0.011	0.07	0.061	0.065	0.151	0.005	0.05	0.003	0.012	0.004	0.047
knowledge	0.063	0.017	0.007	0.185	0.031	0.057	0.014	0.006	0.118	0.021	0.096	0.046
Connected	0.011	0.005	0.065	0.02	0.088	0.005	0.03	0.01	0.138	0.007	0.035	0.046
reference	0.034	0.017	0.075	0.049	0.036	0.05	0.028	0.025	0.045	0.007	0.029	0.046
extension	0.018	0.031	0.07	0.026	0.041	0.022	0.081	0.028	0.024	0.004	0.062	0.045
enable	0.018	0.041	0.039	0.005	0.013	0.011	0.005	0.028	0.041	0.002	0.027	0.045
stability	0.054	0.128	0.07	0.016	0.051	0.031	0.037	0.003	0.099	0.103	0.023	0.045
recent	0.046	0.011	0.166	0.08	0.087	0.052	0.035	0.026	0.031	0.034	0.016	0.045
infrared	0.036	0.046	0.033	0.02	0.025	0.001	0.026	0.017	0.066	0.031	0.132	0.044
matched	0.013	0.048	0.049	0.131	0	0.111	0.015	0.141	0.023	0.005	0.041	0.044
perform	0.051	0.018	0.016	0.003	0.056	0.003	0.004	0.017	0.193	0.019	0.012	0.044
years	0.001	0.008	0.192	0.003	0.041	0.021	0.067	0.013	0.027	0.022	0.008	0.044
LANs	0.003	0.146	0.065	0.028	0.039	0.036	0.103	0.011	0.013	0.032	0.173	0.043
standard	0.004	0.126	0.135	0.029	0.021	0.099	0.14	0.012	0.016	0.051	0.137	0.043
reduce	0.061	0.04	0.023	0.055	0.022	0.068	0.075	0.068	0.088	0.068	0.116	0.043
two	0.014	0.084	0.011	0.069	0.028	0.055	0.068	0.087	0.112	0.15	0.051	0.043
overview	0.025	0.02	0.189	0.032	0.026	0.036	0.064	0.02	0.026	0.03	0.03	0.043
offer	0.02	0.019	0.123	0.077	0.03	0.022	0.024	0.001	0.024	0.021	0.019	0.043
complete	0.015	0.024	0.059	0.027	0.082	0.194	0.014	0.039	0.018	0.019	0.018	0.043
superior	0.093	0.024	0.007	0.148	0.005	0.055	0.051	0.011	0.011	0.044	0.017	0.043
set	0	0.04	0.049	0.042	0.017	0.043	0.015	0.021	0.146	0.065	0.001	0.043
free	0.022	0.085	0.011	0.017	0.057	0.021	0.001	0.001	0.001	0.086	0.093	0.042
message	0.008	0.173	0.045	0.003	0.067	0.03	0.02	0.022	0.076	0.066	0.035	0.042
features	0.003	0.036	0.145	0.009	0.005	0.023	0.028	0.003	0.028	0.011	0.011	0.042
soft	0.003	0.054	0.008	0.023	0.033	0.02	0.089	0.062	0	0.032	0.164	0.041
cases	0.025	0.057	0.021	0.007	0.01	0.005	0.034	0.016	0.025	0.163	0.037	0.041
buffer	0.08	0.051	0.081	0.04	0.049	0.001	0.123	0.061	0.005	0.035	0.023	0.041
functions	0.027	0.027	0.086	0.043	0.027	0.071	0.097	0.062	0	0.033	0.001	0.041
implementation	0.013	0.008	0.138	0.093	0.131	0.145	0.009	0.071	0.004	0.031	0.075	0.04
concept	0.001	0.008	0.176	0.004	0.085	0.017	0.103	0.033	0.014	0.009	0.064	0.04

end-to-end	0.108	0.035	0.025	0.022	0.029	0.034	0.123	0.058	0.167	0.009	0.061	0.04
first	0.015	0.088	0.065	0.089	0.063	0.063	0.053	0.044	0.035	0.085	0.039	0.04
loop	0.009	0.002	0.003	0.009	0.023	0.177	0.061	0.022	0.041	0.013	0.005	0.04
factors	0.002	0.045	0.004	0.038	0.02	0.018	0.005	0.013	0.001	0.104	0.002	0.04
framework	0.051	0.007	0.131	0.015	0.016	0.052	0.134	0.043	0.106	0.107	0.047	0.039
choice	0.082	0.035	0.077	0.006	0.019	0.02	0.016	0.016	0.017	0.073	0.031	0.039
home	0.012	0.025	0.095	0.037	0.078	0.024	0.029	0.006	0.162	0.008	0.014	0.039
fundamental	0.045	0.025	0.104	0.039	0.032	0.086	0.056	0.016	0.033	0.062	0.008	0.039
PCS	0.036	0.025	0.168	0.043	0.005	0.121	0.058	0.06	0.021	0.013	0.111	0.038
maximum	0.031	0.088	0.062	0.08	0.051	0.08	0.094	0.162	0.029	0.064	0.005	0.038
times	0.019	0.058	0.047	0.035	0.012	0.045	0.08	0.067	0.006	0.042	0.002	0.038
context	0.015	0.034	0.135	0.059	0.017	0.012	0.032	0.047	0	0.067	0.001	0.038
assigned	0.049	0.138	0.017	0	0.027	0.019	0.03	0.032	0.021	0.033	0.139	0.037
consideration	0.003	0.049	0.046	0.006	0.006	0.022	0.02	0.007	0.015	0.064	0.047	0.037
core	0.073	0.054	0.173	0.047	0.018	0.007	0.076	0.022	0.068	0.051	0.038	0.037
classes	0.035	0.126	0.03	0.004	0.074	0.004	0.149	0.081	0.001	0.085	0.025	0.037
higher	0.198	0.09	0.048	0.003	0.033	0.076	0.019	0.049	0.023	0.066	0.02	0.037
security	0.011	0.06	0.14	0.034	0.117	0.022	0.08	0	0.135	0.024	0.012	0.037
WLANs	0.041	0.117	0.081	0.002	0.015	0.065	0.09	0.003	0.033	0.033	0.184	0.036
electronic	0.003	0.018	0.132	0.017	0.017	0.038	0.103	0.003	0.031	0.008	0.067	0.036
variations	0.034	0.016	0.003	0.026	0.017	0.024	0.034	0.02	0.004	0.086	0.03	0.036
examples	0.005	0.02	0.036	0.019	0.02	0.024	0	0.031	0.024	0.126	0.024	0.036
bursty	0.146	0.127	0.011	0.007	0.024	0.028	0.043	0.021	0.005	0.049	0.004	0.036
availability	0.017	0.024	0.099	0.037	0.013	0.007	0.023	0.012	0.039	0.076	0.001	0.036
Mb/s	0.041	0.022	0.123	0.076	0.087	0.069	0.01	0.014	0.061	0.024	0.173	0.035
modeled	0.019	0.032	0.039	0.051	0.017	0.029	0.009	0.028	0.012	0.154	0.029	0.035
simple	0.033	0.011	0.019	0.157	0.048	0.02	0.002	0	0.008	0.136	0.014	0.035
main	0.029	0.005	0.089	0.07	0	0.034	0.029	0.009	0.064	0.088	0.01	0.035
delivery	0.072	0.057	0.039	0.028	0.091	0.035	0.022	0.039	0.118	0.026	0.008	0.035
addition	0.037	0.047	0.072	0.031	0.029	0.038	0.004	0.004	0.063	0.073	0.074	0.034
realize	0.004	0.071	0.06	0.039	0.012	0.08	0.012	0.026	0.004	0.042	0.041	0.034
reducing	0.034	0.018	0.042	0.056	0.015	0.016	0.014	0.065	0.035	0.017	0.036	0.034
alternative	0.019	0.021	0.092	0.09	0.004	0.005	0.01	0.04	0.06	0.038	0.022	0.034
focus	0.009	0.03	0.147	0.005	0.019	0.009	0.014	0.018	0.049	0.1	0.013	0.034
commercial	0.015	0.035	0.164	0.016	0.004	0.104	0.081	0.006	0.026	0.01	0.002	0.034
leads	0.025	0.021	0.012	0.063	0.022	0.017	0.036	0.01	0.007	0.108	0	0.034
flexibility	0.034	0.003	0.161	0.05	0.004	0.005	0.024	0.044	0.032	0.017	0.083	0.033
manner	0.043	0.098	0.024	0.015	0.056	0.013	0.05	0.05	0.053	0.037	0.012	0.033
real	0.006	0.148	0.035	0.034	0.023	0.002	0.114	0.024	0.081	0.011	0.041	0.032
supported	0.012	0.06	0.113	0.038	0.044	0.041	0.048	0.009	0.044	0.023	0.022	0.032
value	0.015	0.039	0.028	0.008	0.066	0.067	0.041	0.073	0.004	0.065	0.009	0.032
rates	0.155	0.06	0.099	0.086	0.115	0.056	0.063	0.025	0.057	0.046	0.004	0.032
factor	0.004	0.028	0.004	0.014	0.014	0.053	0.022	0.135	0.054	0.041	0.083	0.031
low-cost	0.025	0.019	0.079	0.003	0.039	0.16	0.039	0.019	0.01	0.01	0.078	0.031
losses	0.196	0.051	0.025	0.013	0	0.041	0.052	0.025	0.064	0.107	0.016	0.031
illustrate	0.043	0.02	0.045	0.116	0.043	0.046	0.004	0.022	0.044	0.055	0.016	0.031
necessary	0.142	0.004	0.036	0.013	0.045	0.013	0.08	0.061	0.073	0.018	0.004	0.031
transmitting	0.088	0.151	0.063	0.038	0.012	0.05	0.056	0.051	0.012	0.046	0.048	0.03
space	0.021	0.048	0.034	0.117	0.004	0.064	0.044	0.132	0.007	0.094	0.035	0.03
operation	0.027	0.05	0.107	0.011	0.019	0.126	0.003	0.081	0.075	0.018	0.021	0.03
information	0.075	0.077	0.073	0.102	0.109	0.008	0.05	0.02	0.199	0.001	0.104	0.029
basis	0.017	0.001	0.035	0.03	0.025	0	0.017	0.019	0.01	0.052	0.044	0.029
scenario	0.001	0.058	0.082	0.066	0.014	0.032	0.034	0.001	0.023	0.038	0.033	0.029
accuracy	0.028	0.011	0.067	0.046	0.064	0.028	0.052	0.109	0.058	0.047	0.008	0.029
strategies	0.052	0.036	0.024	0.059	0.048	0.021	0.014	0.022	0.062	0.056	0.002	0.029
propose	0.017	0.133	0.062	0.104	0.088	0.04	0.138	0.088	0.15	0.017	0.067	0.028
uses	0.04	0.099	0.04	0.061	0.071	0.003	0.041	0.004	0.103	0.078	0.042	0.028
sharing	0.061	0.12	0.041	0	0.061	0.002	0.062	0.007	0.008	0.049	0.033	0.028
statistical	0.006	0.035	0.011	0.014	0.021	0.014	0.111	0.043	0.057	0.112	0.032	0.028
objective	0.029	0.006	0.02	0.037	0.015	0.014	0.118	0.034	0.004	0.097	0.006	0.028
modified	0.049	0.042	0.041	0.024	0.016	0.015	0	0.005	0.003	0.014	0.005	0.028
analytically	0.009	0.065	0.019	0.006	0.005	0.017	0.045	0.032	0.02	0.161	0.078	0.027
controlled	0.02	0.03	0.033	0.046	0.066	0.132	0.017	0.089	0.043	0.07	0.063	0.027
ability	0.066	0.055	0.089	0.021	0.014	0.022	0.018	0.02	0.016	0.007	0.061	0.027
process	0.008	0.076	0.012	0.006	0.044	0.114	0.013	0.027	0.036	0.17	0.044	0.027
constraints	0.009	0.004	0.082	0.001	0.033	0.025	0.024	0.027	0.063	0.022	0.038	0.027
supports	0.001	0.076	0.116	0.056	0.012	0.039	0.1	0.049	0.072	0.052	0.023	0.027
stable	0.052	0.111	0.06	0.007	0.078	0.007	0.001	0.01	0.174	0.065	0.014	0.027
current	0.022	0.005	0.155	0.073	0.042	0.1	0.002	0.012	0.179	0.034	0.014	0.027
short	0.055	0.051	0.008	0.028	0.024	0.069	0.001	0.013	0.028	0.065	0.013	0.027
backbone	0.027	0.006	0.122	0.056	0.037	0.011	0.149	0.068	0.1	0.01	0.002	0.027

integration	0.052	0.068	0.105	0.043	0.039	0.088	0.066	0.086	0.045	0.04	0.001	0.027
means	0.025	0.027	0.054	0.076	0.016	0.021	0.004	0.093	0.024	0.131	0.042	0.026
operations	0.018	0.008	0.043	0.034	0.04	0.082	0.011	0.018	0.1	0.016	0.021	0.026
type	0.084	0.049	0.008	0.011	0.02	0.052	0.009	0.005	0.02	0.057	0.019	0.026
centralized	0.031	0.142	0.044	0.011	0.029	0.016	0.034	0.025	0.125	0.046	0.048	0.025
overcome	0.021	0.018	0.009	0.034	0.024	0.009	0.014	0.015	0.035	0.038	0.001	0.025
configuration	0.007	0.032	0.021	0.042	0.014	0.105	0.104	0.007	0.01	0.006	0.09	0.024
optical	0.014	0.014	0.017	0.01	0.027	0.021	0.034	0.013	0.072	0.021	0.068	0.024
active	0.023	0.078	0.005	0.007	0.022	0.124	0.036	0	0.069	0.029	0.063	0.024
amount	0.082	0.065	0.029	0.014	0.041	0.045	0.034	0.024	0.088	0.022	0.056	0.024
detailed	0.015	0.003	0.025	0.005	0.047	0.012	0.039	0.019	0.031	0.087	0.035	0.024
high	0.173	0.101	0.121	0.092	0.043	0.146	0.053	0.008	0.006	0.01	0.015	0.024
measured	0.033	0.005	0.037	0.016	0.044	0.12	0.116	0.098	0.07	0.062	0.16	0.023
optimum	0.027	0.015	0.05	0.045	0.015	0.05	0.032	0.034	0.004	0.076	0.09	0.023
capable	0.016	0.019	0.149	0.084	0.013	0.021	0.06	0.05	0.062	0.022	0.067	0.023
media	0.095	0.15	0.049	0.017	0.068	0.024	0.029	0.046	0.025	0.007	0.061	0.023
traditional	0.046	0.002	0.038	0.024	0.022	0.032	0.014	0.027	0.125	0.04	0.058	0.023
implementing	0.031	0.033	0.1	0.001	0.067	0.024	0.088	0.045	0.013	0.012	0.053	0.023
hardware	0.08	0.019	0.045	0.063	0.043	0.084	0.042	0.011	0	0.047	0.047	0.023
version	0.082	0.011	0.011	0.049	0.002	0.034	0.026	0.022	0.084	0.057	0.037	0.023
rapid	0.007	0.026	0.13	0.047	0.007	0.01	0.022	0.018	0.013	0.048	0.003	0.023
independent	0.024	0.034	0.037	0.01	0.002	0.062	0.004	0.063	0.006	0.152	0.001	0.023
test	0.011	0.004	0.021	0.052	0.015	0.059	0.03	0.002	0.075	0.026	0.001	0.022
characteristics	0.047	0.02	0.064	0.032	0.021	0.055	0.021	0.012	0.003	0.149	0.111	0.021
numerical	0.004	0.156	0.073	0.011	0.013	0.037	0.01	0.026	0.105	0.192	0.057	0.021
similar	0.027	0.004	0.023	0.012	0.048	0.011	0.011	0.048	0.02	0.009	0.05	0.021
enhance	0.015	0.031	0.055	0.024	0.005	0.02	0.028	0.022	0.026	0.04	0.048	0.021
example	0.026	0.018	0.094	0.016	0.012	0.046	0.033	0.028	0.001	0.126	0.04	0.021
open	0.029	0.035	0.177	0.051	0.005	0.011	0.013	0.019	0.079	0.01	0.022	0.021
communication	0.033	0.057	0.151	0.103	0.067	0.093	0.056	0.018	0.03	0.09	0.107	0.02
condition	0.09	0.055	0.044	0.015	0.046	0.029	0.01	0.019	0.055	0.064	0.067	0.02
introduce	0.027	0.051	0.018	0.025	0.104	0.006	0.019	0.024	0.097	0.058	0.034	0.02
reduction	0.028	0.003	0.024	0.017	0.027	0.05	0.013	0.044	0.034	0.021	0.061	0.019
scenarios	0.033	0.031	0.107	0.083	0.017	0.068	0.022	0.002	0.003	0.022	0.037	0.019
single	0.01	0.065	0.012	0.064	0.031	0.129	0.008	0.028	0.038	0.089	0.035	0.019
broadcast	0.052	0.074	0.005	0.006	0.036	0.027	0.083	0.017	0.152	0.012	0.034	0.019
novel	0.07	0.078	0.026	0.106	0.068	0.015	0.064	0.071	0.002	0.041	0.029	0.019
structure	0.022	0.006	0.003	0.176	0.026	0.015	0.002	0.009	0.023	0.046	0.013	0.019
literature	0.018	0.018	0.041	0.026	0.048	0.051	0.039	0.027	0.015	0.089	0	0.019
terminal	0.019	0.11	0.114	0.015	0	0.019	0.072	0.007	0.011	0.018	0	0.019
accommodate	0.084	0.056	0.056	0.008	0.015	0	0.072	0.045	0.031	0.026	0.123	0.018
part	0.051	0.011	0.148	0.035	0.037	0.062	0.001	0.024	0.011	0.076	0.088	0.018
applying	0.016	0.069	0.007	0.074	0.005	0.017	0.018	0.035	0.05	0.007	0.07	0.018
meet	0.067	0.027	0.123	0.019	0.036	0.071	0.041	0.051	0.022	0.017	0.052	0.018
variation	0.043	0.032	0.058	0.019	0.038	0.008	0.079	0.053	0.042	0.114	0.049	0.018
adaptation	0.102	0.009	0.037	0.155	0.012	0.074	0.077	0.064	0.091	0	0.044	0.018
switched	0.057	0.002	0.054	0.023	0.002	0.05	0.139	0.027	0.022	0.037	0.016	0.018
compare	0.05	0.089	0.013	0.02	0.058	0.039	0.023	0.014	0.101	0.069	0.007	0.018
close	0.018	0.077	0.015	0.003	0.012	0.047	0.039	0.044	0.043	0.113	0.002	0.018
total	0.014	0.001	0.052	0.009	0.036	0.127	0.052	0.039	0.006	0.076	0.106	0.017
extended	0.037	0.017	0.007	0.074	0.083	0.013	0.079	0	0.014	0.054	0.034	0.017
role	0	0.008	0.14	0.022	0.049	0.021	0.027	0.01	0.011	0.03	0.026	0.017
heterogeneous	0.024	0.05	0.07	0.02	0.069	0.034	0.155	0.061	0.006	0.015	0.019	0.017
operate	0.035	0.045	0.076	0.002	0.026	0.063	0.01	0.005	0.076	0.032	0.004	0.017
convergence	0.034	0.039	0.129	0.099	0.029	0.041	0.019	0.016	0.045	0	0.004	0.017
ideal	0	0.022	0.012	0.085	0.003	0.003	0.004	0.093	0	0.105	0.001	0.017
adjacent	0.011	0.008	0.021	0.006	0.032	0.089	0.026	0.023	0.016	0.078	0.114	0.016
point	0.026	0.097	0.055	0.078	0.036	0.083	0.006	0.012	0.001	0.102	0.06	0.016
capability	0.017	0.005	0.091	0.033	0.037	0.061	0.001	0.015	0.031	0.003	0.047	0.016
constraint	0.026	0.029	0.044	0.028	0.039	0.002	0.095	0.004	0.025	0.043	0.043	0.016
accurate	0.029	0.009	0.033	0.017	0.029	0.007	0.021	0.004	0.03	0.141	0.029	0.016
extensive	0.033	0.113	0.049	0.034	0.071	0.038	0.04	0.005	0.012	0.002	0.027	0.016
capabilities	0.016	0.009	0.163	0.075	0.006	0.01	0.107	0.032	0.049	0.005	0.021	0.016
corresponding	0.04	0.03	0.018	0.019	0.008	0.001	0.04	0.002	0.01	0.067	0.098	0.015
increases	0.014	0.037	0.051	0.047	0.031	0.051	0.049	0	0.027	0.057	0.095	0.015
BEST	0.048	0.044	0.015	0.027	0.057	0.039	0.034	0.004	0.068	0.11	0.053	0.015
general	0.008	0.024	0.066	0.051	0.017	0.013	0.053	0.036	0.08	0.193	0.035	0.015
optimization	0.026	0.048	0.004	0.044	0.049	0.054	0.066	0.029	0.066	0.058	0.031	0.015
types	0.015	0.111	0.09	0.014	0.012	0.02	0.029	0.017	0.017	0.062	0.016	0.015

relative	0.018	0.034	0.04	0.06	0.001	0.015	0.039	0.036	0.011	0.063	0.002	0.015
transmissions	0.085	0.171	0.049	0.118	0.027	0.053	0.04	0.023	0.042	0.032	0.033	0.014
gains	0.012	0.022	0.003	0.167	0.03	0.044	0.007	0.051	0.043	0.011	0.027	0.014
period	0.033	0.113	0.041	0.012	0.022	0.012	0.092	0.146	0.027	0.003	0.022	0.014
address	0.022	0.021	0.155	0	0.08	0.037	0.007	0.014	0.186	0.01	0.014	0.014
threshold	0.016	0.013	0.05	0.006	0.035	0.053	0.013	0.069	0.065	0.13	0.006	0.014
measures	0.034	0.071	0.019	0.014	0.016	0.008	0.003	0.058	0.001	0.119	0	0.014
theory	0.046	0.008	0.004	0.05	0.002	0.067	0.001	0.015	0.035	0.181	0.083	0.013
practical	0.026	0.011	0.049	0.104	0	0.048	0.011	0.057	0.033	0.084	0.077	0.013
basic	0.037	0.08	0.04	0.006	0.026	0.009	0.021	0.004	0.029	0.043	0.034	0.013
guarantees	0.01	0.132	0.033	0.039	0.058	0.04	0.137	0.051	0.058	0.024	0.034	0.013
conditions	0.114	0.12	0.012	0.059	0.036	0.022	0.028	0.009	0.045	0.083	0.026	0.013
implement	0.003	0.036	0.009	0.062	0.051	0.035	0.033	0.045	0.035	0.051	0.016	0.013
caused	0.118	0.008	0.031	0.028	0.018	0.059	0.006	0.024	0.002	0.059	0.003	0.013
TDMA	0.013	0.168	0.095	0.066	0.071	0.003	0.014	0.063	0.073	0.008	0.115	0.012
prototype	0.009	0.023	0.093	0.037	0.036	0.039	0.082	0.042	0.034	0.096	0.091	0.012
introduces	0.011	0.016	0.06	0.058	0.082	0.018	0.007	0.026	0.102	0.003	0.079	0.012
properties	0.029	0.025	0.025	0.106	0.025	0.012	0.006	0.033	0.001	0.114	0.076	0.012
individual	0.031	0.029	0.029	0.047	0.053	0.036	0.018	0.021	0.011	0.045	0.055	0.012
level	0.064	0.04	0.024	0.025	0.043	0.141	0.027	0.017	0.102	0.09	0.042	0.012
feasibility	0.024	0.037	0.092	0.061	0.011	0.001	0.06	0.045	0.037	0.003	0.039	0.012
letter	0.052	0.023	0.064	0.012	0.05	0.051	0.015	0.022	0.035	0.026	0.035	0.012
burst	0.147	0.084	0.023	0.048	0.033	0.004	0.033	0.004	0.021	0.002	0.034	0.012
finite	0.066	0.115	0.076	0.017	0.002	0.004	0.027	0.008	0.003	0.189	0.026	0.012
need	0.025	0.009	0.134	0.029	0.011	0.026	0.057	0.043	0.179	0.005	0.015	0.012
Intelligent	0.007	0.034	0.128	0.031	0.062	0.013	0.072	0.051	0.038	0.03	0.005	0.012
smaller	0.038	0.002	0.07	0.04	0.047	0.012	0.024	0.008	0.105	0.02	0.082	0.011
speed	0.11	0.029	0.066	0.081	0.007	0.1	0.019	0.031	0.001	0.007	0.077	0.011
demand	0.035	0.052	0.156	0.027	0.019	0.017	0.062	0.059	0.06	0.03	0.075	0.011
requirement	0.076	0.074	0.06	0.013	0.027	0.006	0.087	0.047	0.023	0.004	0.056	0.011
John	0.018	0.041	0.029	0.011	0.073	0.004	0.026	0.036	0.066	0.021	0.051	0.011
designing	0.009	0.012	0.077	0.018	0.086	0.021	0.044	0.007	0.024	0.015	0.048	0.011
group	0.041	0.083	0.077	0.02	0.069	0.023	0.042	0.005	0.183	0.024	0.043	0.011
switching	0.01	0.002	0.084	0.065	0.018	0.066	0.148	0.076	0.002	0.054	0.018	0.011
effectiveness	0.015	0.052	0.009	0.021	0.047	0.014	0.082	0.005	0.009	0.031	0.01	0.011
downlink	0.014	0.095	0.009	0.143	0.055	0.022	0.038	0.024	0.028	0.019	0.189	0.01
solutions	0.011	0.044	0.193	0.018	0.059	0.007	0.012	0.038	0.064	0.004	0.067	0.01
building	0.003	0.034	0.056	0.009	0.028	0.071	0.008	0.021	0.056	0.042	0.064	0.01
good	0.095	0.09	0.024	0.079	0.019	0.026	0.002	0.02	0.022	0.015	0.036	0.01
specific	0.004	0.026	0.141	0.004	0.016	0.003	0.057	0.01	0.01	0.095	0.034	0.01
addresses	0.004	0.019	0.107	0.031	0.034	0.023	0.105	0.02	0.057	0.006	0.019	0.01
least	0.011	0.035	0.047	0.189	0.002	0.013	0.025	0.019	0.05	0.041	0.017	0.01
wide	0.046	0.023	0.161	0.014	0.063	0.089	0.039	0.015	0.01	0.048	0.032	0.009
issue	0.032	0.025	0.141	0.038	0.012	0.008	0.055	0.01	0.106	0.132	0.031	0.009
upper	0.012	0.081	0.065	0.017	0.009	0.012	0.038	0.001	0.043	0.183	0.002	0.009
third	0.048	0.042	0.184	0.021	0.027	0	0.02	0.031	0.031	0.002	0.131	0.008
physical	0.119	0.09	0.121	0.032	0.026	0.013	0.01	0.081	0.025	0.035	0.129	0.008
realistic	0.008	0.028	0.029	0.003	0.003	0.042	0.012	0.004	0.018	0.11	0.062	0.008
reliability	0.091	0.007	0.022	0.006	0.057	0.001	0.015	0.006	0.067	0.056	0.045	0.008
performs	0.001	0.092	0.052	0.014	0.054	0.015	0	0.027	0.082	0.015	0.032	0.008
shared	0.022	0.178	0.014	0.017	0.065	0.013	0.008	0.02	0.125	0.004	0.032	0.008
varying	0.107	0.076	0.009	0.159	0.049	0.013	0.02	0.036	0.035	0.017	0.096	0.007
improvements	0.033	0.049	0.016	0.025	0.019	0.009	0.037	0.015	0.064	0.09	0.025	0.007
state	0.02	0.048	0.011	0.01	0.073	0.021	0.024	0.001	0.144	0.128	0.023	0.007
decrease	0.018	0.093	0.036	0.037	0.01	0.039	0.039	0.151	0.003	0.017	0.016	0.007
methods	0.016	0.002	0.004	0.097	0.025	0.008	0.002	0.02	0.003	0.105	0.01	0.007
second	0.038	0.053	0.052	0.086	0.007	0.059	0.031	0.013	0.051	0.043	0.001	0.007
strategy	0.071	0.039	0.015	0.002	0.024	0.039	0.003	0.031	0.055	0.035	0.102	0.006
target	0.024	0.014	0.03	0.012	0.009	0.011	0.104	0.173	0.03	0.052	0.039	0.006
Markov	0.059	0.194	0.086	0.086	0.031	0.063	0.081	0.002	0.012	0.17	0.001	0.006
component	0.007	0.017	0.084	0.084	0.028	0.068	0.012	0.02	0.025	0.023	0.057	0.005
specified	0.12	0.024	0.022	0.027	0.012	0	0.061	0.049	0.01	0.107	0.049	0.005
special	0.022	0.035	0.086	0.024	0.019	0.003	0.021	0.017	0.081	0.045	0.043	0.005
lower	0.049	0.009	0.09	0.089	0.002	0.069	0.041	0.009	0.012	0.09	0.011	0.005
rapidly	0.036	0.01	0.089	0.041	0.036	0.025	0.006	0.002	0.055	0.005	0.011	0.005
view	0.002	0.01	0.098	0.034	0.046	0.01	0.001	0.014	0.006	0.037	0.001	0.005
overall	0.024	0.023	0.062	0.01	0.005	0.021	0.02	0.004	0.05	0.037	0.081	0.004
optimal	0.055	0.002	0.053	0.07	0.036	0.007	0.062	0.003	0.057	0.139	0.079	0.004
feature	0.003	0.022	0.007	0.049	0.017	0.01	0.035	0.053	0.125	0.009	0.068	0.004
robustness	0.027	0.027	0.006	0.185	0.048	0.032	0.011	0.014	0.057	0.019	0.034	0.004

common	0.014	0.095	0.065	0.025	0.048	0.04	0.021	0.057	0.019	0.043	0.012	0.004
available	0.004	0.089	0.139	0.016	0.011	0.03	0.122	0.065	0.023	0.021	0.011	0.004
heavy	0.033	0.192	0.055	0.033	0.015	0.026	0.011	0.005	0.044	0.043	0.004	0.004
adopted	0.007	0.054	0.045	0.013	0.022	0.002	0.015	0.008	0.022	0.031	0.004	0.004
reduces	0.018	0.014	0.059	0.013	0.017	0.044	0.064	0.022	0.079	0.019	0.099	0.003
order	0.108	0.092	0.042	0.076	0.012	0.034	0.079	0.057	0.018	0.05	0.095	0.003
avoid	0.041	0.104	0.071	0.012	0.012	0.029	0.047	0.009	0.025	0.017	0.058	0.003
utilization	0.039	0.162	0.017	0.022	0.085	0.026	0.164	0.067	0.051	0.011	0.056	0.003
conducted	0.012	0.049	0.058	0.009	0.026	0.026	0.054	0.128	0.012	0.044	0.035	0.003
i.e	0.05	0.143	0.006	0.043	0.004	0.005	0.043	0.183	0.02	0.047	0.025	0.003
optimized	0.027	0.01	0.078	0.019	0	0.074	0.039	0.058	0.033	0.004	0.011	0.003
region	0.001	0.045	0.043	0.001	0.02	0.01	0.031	0.019	0.085	0.146	0.061	0.002
critical	0.019	0.021	0.031	0.009	0.041	0.041	0.057	0.004	0.032	0.054	0.015	0.002
established	0.028	0.007	0.029	0.012	0.036	0.004	0.043	0.027	0.079	0	0.01	0.002
bound	0.019	0.065	0.039	0.032	0.008	0.002	0.059	0.011	0.005	0.144	0.005	0.002
dynamically	0.038	0.148	0.034	0.006	0.02	0.042	0.053	0.065	0.154	0.03	0.033	0.001
work	0.015	0.051	0.09	0.04	0.056	0.007	0.041	0.028	0.069	0.091	0.029	0.001
impact	0.079	0.017	0.078	0.039	0.02	0.017	0.034	0.023	0.02	0.141	0.028	0.001
modeling	0.036	0.029	0.028	0.023	0.026	0.002	0.051	0.066	0.032	0.196	0.019	0.001
sources	0.019	0.113	0.002	0.002	0.042	0.009	0.09	0.063	0.043	0.064	0.011	0.001
form	0.008	0.012	0.041	0.045	0.017	0.047	0.01	0.006	0.068	0.139	0.031	0
limited	0.095	0.066	0.056	0.064	0.038	0.048	0.082	0.035	0.015	0.066	0.024	0
class	0.035	0.056	0.011	0.024	0.057	0.01	0.09	0.067	0.042	0.107	0.015	0
new	0.01	0.068	0.106	0.04	0.073	0.021	0.098	0.086	0.156	0.013	0.009	0
one	0.007	0.139	0.098	0.065	0.023	0.022	0.029	0.023	0.065	0.084	0.005	0
carried	0.024	0.068	0.01	0.072	0.04	0.041	0.021	0.028	0.055	0.022	0.005	0

Appendix 8 – Phrase Factor Matrix

Factor	1	2	3	4	5	6	7	8	9	10	11	12
quality-of-service QoS	0.36	0.03	0.04	0.03	0	0.01	0.05	0.03	0.03	0.05	0.03	0.06
wired network	0.35	0.02	0.02	0.04	0	0.01	0.06	0.08	0.05	0.02	0.02	0
frequency domain	0.3	0.01	0.02	0.01	0.01	0	0.03	0.06	0.03	0.01	0.01	0.04
single cell	0.29	0.02	0.02	0.01	0.01	0.01	0.03	0.03	0.02	0.02	0.03	0.04
FDMA	0.27	0	0.03	0.05	0.01	0	0.02	0.05	0.01	0.02	0.01	0.04
computer simulation	0.27	0.04	0.01	0	0.04	0	0.05	0.01	0.01	0.02	0.01	0
location information	0.25	0.01	0.02	0.02	0.02	0.01	0.01	0.03	0.02	0.01	0	0.01
CDMA systems	0.25	0.03	0.01	0.09	0.13	0.06	0.04	0.04	0.03	0.13	0.09	0.2
transmission performance	0.24	0.01	0.02	0.05	0.01	0.04	0	0.01	0.02	0.09	0.02	0.02
power control TPC	0.23	0.01	0.01	0.02	0.01	0.01	0	0	0	0.01	0.02	0.01
broadband	0.23	0.01	0.02	0.07	0.03	0.03	0.02	0.01	0.04	0.02	0	0.11
base station	0.22	0.43	0.01	0.02	0.03	0	0.02	0.04	0.01	0.03	0.04	0.02
MC-CDMA	0.21	0.01	0.02	0.05	0.03	0.01	0.01	0	0.04	0.03	0.01	0.05
adaptive antenna arrays	0	0.74	0.05	0.01	0.03	0.03	0.02	0.05	0.01	0.02	0.06	0
orthogonality	0.05	0.67	0.15	0	0.04	0.01	0.02	0.08	0.04	0.03	0.13	0.04
code division multiple access CDMA	0.04	0.66	0.08	0.01	0.04	0.05	0.07	0	0.01	0.02	0.06	0.03
available bandwidth	0.01	0.65	0.03	0.01	0.04	0.02	0	0	0.06	0.01	0.03	0.01
distribution	0	0.62	0.03	0.01	0.03	0.01	0.01	0.03	0.01	0.02	0.05	0
handoff calls	0.06	0.61	0.25	0	0.05	0	0.03	0.08	0.04	0.05	0.23	0.03
mobile station	0.01	0.6	0.06	0.05	0.01	0.03	0.01	0.05	0.03	0.01	0.03	0.04
broadband wireless access systems	0	0.49	0.09	0.01	0.06	0.02	0.09	0.02	0.05	0.03	0.07	0.05
smart antennas	0.07	0.45	0.06	0.01	0.02	0.01	0.04	0.14	0	0.05	0.06	0.02
admission control	0.03	0.36	0.04	0.04	0.01	0	0.07	0.01	0.01	0.1	0.01	0
higher data rates	0.01	0.32	0.01	0	0.02	0.01	0.12	0.13	0.08	0.01	0	0.02
co-channel interference	0.06	0.31	0.11	0.02	0.04	0.06	0.2	0.02	0.01	0.04	0.07	0.05
reverse links	0.03	0.3	0.01	0.01	0.02	0.04	0	0.04	0.02	0.01	0.04	0.01
cells	0.11	0.26	0.26	0.02	0.01	0.14	0.1	0.06	0.07	0.06	0.22	0.05
proposed protocol	0.11	0.24	0.03	0.02	0.05	0.04	0.02	0.01	0.03	0.03	0.01	0.2
new calls	0.06	0.23	0.28	0.01	0.04	0.02	0.03	0.07	0.02	0.08	0.26	0.02
power	0.05	0.22	0.02	0.1	0.11	0.05	0.09	0.15	0.06	0.01	0.03	0
neighboring cells	0.06	0	0.45	0	0.02	0.01	0.02	0.03	0.02	0	0.45	0.05
reverse link	0.02	0.07	0.43	0.03	0.01	0.07	0.02	0.04	0.03	0.05	0.42	0.05
forward link	0	0.02	0.41	0	0.02	0.05	0.04	0.09	0.04	0.03	0.39	0
system capacity	0.04	0.11	0.41	0.04	0.02	0.05	0.02	0.03	0.02	0.1	0.41	0.01
mobile	0.04	0.05	0.39	0.02	0.03	0.04	0.01	0.07	0.01	0.01	0.37	0.02
probability	0.05	0	0.38	0.02	0	0.01	0.01	0.02	0.02	0	0.37	0.02
handoffs	0.01	0.02	0.38	0.05	0.01	0	0.02	0.04	0.02	0	0.35	0.1
interference	0.07	0	0.35	0.03	0	0.01	0.01	0.02	0.04	0.03	0.32	0.03
forward link capacity	0.09	0.01	0.35	0.01	0.02	0	0.01	0.04	0.01	0.02	0.35	0.05
Rayleigh fading	0.07	0.02	0.33	0.02	0.01	0.02	0	0.03	0	0.02	0.33	0.11
downlink	0.06	0	0.32	0.01	0.01	0.01	0	0.03	0.01	0.01	0.32	0.01
soft handoff	0.04	0.04	0.31	0	0.03	0	0.04	0.01	0.04	0.04	0.29	0.01
mobiles	0.05	0	0.31	0	0.01	0	0	0.04	0	0.01	0.34	0.05
switches	0.04	0.01	0.3	0.03	0.02	0	0.01	0.03	0	0.01	0.29	0.05
background noise	0.05	0.12	0.3	0	0.03	0	0.04	0.05	0.03	0.06	0.27	0.03
capture effect	0.01	0	0.29	0.03	0.03	0	0.02	0.01	0.02	0.03	0.25	0.11
higher capacity	0.1	0.06	0.28	0.07	0.03	0.19	0.13	0.03	0.06	0.01	0.22	0.03
fading	0.06	0.01	0.26	0	0.02	0.03	0.01	0.03	0.01	0.04	0.27	0.04
high data rate	0.04	0	0.24	0.01	0.01	0	0.01	0.04	0	0.04	0.23	0.03
call admission control	0.02	0.16	0.23	0.01	0.03	0.06	0.08	0.08	0.09	0.02	0.22	0.02
cellular systems	0.02	0.01	0.22	0	0	0	0.01	0.05	0.01	0.06	0.23	0
multipath fading environments	0.02	0.01	0.22	0.02	0.01	0.02	0	0.01	0.02	0.03	0.23	0
Monte Carlo simulations	0.08	0.14	0.22	0.01	0.01	0.17	0.1	0.11	0	0.07	0.2	0.01
multicast	0.06	0.02	0.21	0.03	0.04	0.03	0	0.03	0.05	0.04	0.2	0.04
energy	0.01	0.01	0.2	0.11	0.09	0	0.01	0.03	0.02	0.01	0.2	0.03
multipath interference	0.05	0.01	0.2	0.04	0.01	0.01	0.03	0.02	0.04	0.02	0.24	0.19
cell	0.06	0	0.02	0.52	0.5	0.03	0.02	0.02	0.02	0.04	0.01	0.02
base stations	0.07	0.01	0.03	0.49	0.46	0.01	0.03	0.03	0	0	0.01	0.04
shadowing	0.01	0.02	0.02	0.44	0.45	0.01	0.01	0.02	0.01	0.01	0.03	0.02
users	0.03	0.01	0.02	0.43	0.4	0.05	0.01	0.01	0.01	0.01	0.03	0.03
orthogonal spreading	0.08	0.02	0.03	0.39	0.37	0.04	0.02	0.02	0.04	0.08	0.01	0.09
uplink	0.04	0	0.02	0.34	0.35	0.02	0.02	0.02	0	0.02	0.02	0
handoff	0.1	0.03	0.03	0.34	0.31	0.05	0.01	0	0.01	0.11	0.04	0.05
imperfect power control	0.09	0.03	0.01	0.31	0.31	0.04	0.13	0.1	0.03	0.06	0.03	0.07
power control	0.08	0.01	0.04	0.31	0.25	0.08	0.01	0.07	0.02	0.17	0	0.1
intercell interference	0.04	0.04	0.04	0.3	0.3	0.04	0.02	0	0.02	0.03	0.04	0.1
CDMA	0.02	0.01	0	0.29	0.27	0.03	0	0.02	0.02	0.03	0.02	0.01
antenna arrays	0.08	0.03	0.03	0.27	0.26	0.04	0.02	0.09	0.03	0.09	0.04	0.03
mobile stations	0.16	0.03	0.04	0.26	0.31	0.02	0.05	0.04	0.01	0	0.01	0.15
wireless ATM networks	0.08	0.01	0.02	0.25	0.25	0.02	0.02	0.04	0.04	0.1	0.02	0.03
log-normal shadowing	0.06	0.05	0.05	0.24	0.21	0.02	0.06	0.02	0.04	0.05	0.02	0.03
delay constraint	0.07	0.01	0.01	0.23	0.16	0.01	0.01	0.02	0.02	0.03	0.02	0.08
link capacity	0.02	0	0	0.23	0.27	0.03	0	0.01	0.03	0.04	0.03	0.09

CDMA system	0.16	0.01	0.02	0.23	0.29	0.03	0.01	0.01	0	0.02	0.02	0.16
CDMA scheme	0.07	0.01	0.03	0.21	0.17	0.17	0.12	0.13	0.02	0.16	0.05	0.13
architecture	0.01	0.02	0.05	0.21	0.19	0.02	0	0.05	0.01	0.02	0.05	0.02
fixed network	0.03	0	0	0.21	0.17	0.04	0.01	0.01	0.03	0.02	0.02	0.04
resolved paths	0.05	0.01	0.01	0.21	0.19	0.01	0.02	0.05	0.17	0.01	0	0
outage probability	0	0.03	0.09	0.2	0.21	0.08	0.03	0.04	0.01	0.14	0.09	0.16
mobile user	0.04	0.01	0.01	0.08	0.21	0.14	0.11	0.07	0.1	0.06	0.01	0.22
power level	0.02	0.01	0.03	0.12	0.2	0.07	0.06	0.05	0.1	0.02	0.01	0.06
multipath diversity	0	0.02	0.04	0.01	0.02	0.54	0.01	0.08	0.04	0.03	0.06	0.1
existing protocols	0.08	0.01	0.07	0.04	0.03	0.52	0.13	0.04	0.03	0.02	0.04	0.07
mobile communications	0.09	0.02	0.05	0.04	0.04	0.45	0.09	0.03	0.02	0.06	0.02	0.13
user mobility	0.04	0.01	0.05	0.07	0.08	0.39	0.07	0.03	0.05	0.05	0.03	0.08
antenna array	0.01	0	0.05	0.01	0.03	0.39	0.02	0.02	0.08	0.18	0.03	0.03
traffic load	0.04	0.02	0.05	0.03	0.02	0.38	0.15	0.06	0	0.03	0.03	0.09
blocking probability	0.06	0.01	0.05	0.01	0.01	0.37	0.24	0.08	0.05	0.07	0.02	0.12
multiple access interference	0.03	0	0.09	0.01	0	0.36	0.04	0.01	0.02	0.03	0.05	0.08
multipath fading	0.15	0.02	0.03	0.05	0.07	0.35	0.1	0.13	0.03	0.02	0.05	0.34
cellular networks	0.15	0.02	0.03	0.06	0.07	0.35	0.1	0.13	0.03	0.03	0.06	0.34
voice activity	0.01	0.01	0.03	0.02	0.03	0.33	0.25	0.03	0	0.06	0.03	0.06
acquisition performance	0.03	0.01	0.02	0.02	0	0.32	0	0.08	0.04	0.02	0.05	0.1
adjacent cells	0.06	0.01	0.04	0.04	0.05	0.29	0.3	0.04	0.02	0.06	0	0.1
personal communications	0.07	0.02	0	0.04	0.04	0.24	0.05	0.01	0.04	0.03	0	0.04
system performance	0.12	0.01	0.02	0.04	0.04	0.23	0.27	0.04	0.1	0.01	0.01	0.13
multipath fading channel	0.05	0.02	0.02	0.01	0.03	0.22	0.08	0.03	0.09	0.04	0	0.04
ALOHA protocol	0.15	0.03	0.03	0.01	0.05	0.2	0	0.06	0.02	0.01	0	0.11
configuration	0.07	0.02	0.04	0.01	0.02	0.2	0.08	0.01	0.03	0.01	0.03	0.09
MANET	0.03	0	0	0	0.01	0.1	0.45	0.01	0	0.04	0.01	0.1
traffic characteristics	0.07	0.01	0	0.04	0.02	0.03	0.4	0.08	0.04	0.01	0	0.03
coverage	0.08	0.01	0.02	0.16	0.16	0.01	0.35	0.02	0.05	0.01	0.01	0.02
spatial diversity	0.03	0.01	0	0.03	0.04	0.02	0.34	0.02	0.04	0.01	0	0.02
delay	0.03	0.03	0.01	0.02	0.05	0.05	0.34	0.05	0.01	0.02	0.01	0.07
mobile communication systems	0.04	0.01	0.02	0.01	0.05	0.02	0.31	0	0.02	0.01	0	0
multimedia communications	0.02	0	0	0.05	0.02	0.07	0.29	0.02	0.04	0.01	0.01	0.02
microcells	0.08	0.01	0.02	0.05	0.03	0.01	0.29	0.07	0.1	0.05	0.01	0.05
multiple-access interference	0.13	0.04	0.12	0.1	0.11	0.03	0.29	0.07	0.01	0.1	0.07	0.03
high bandwidth	0.06	0.01	0.01	0.01	0.05	0.05	0.28	0.06	0.07	0.06	0.03	0.03
CDMA network	0.03	0.03	0.01	0.01	0.05	0.02	0.28	0.02	0.01	0.1	0.02	0.04
rerouting	0.12	0.18	0.11	0.01	0.02	0.11	0.27	0.21	0.05	0.02	0.05	0.03
CDMA cellular system	0.06	0.02	0	0.04	0.02	0.03	0.25	0.08	0.03	0.32	0.01	0.08
mobile subscribers	0.03	0.01	0.02	0.01	0.02	0.07	0.23	0	0.01	0.04	0.02	0.04
statistical multiplexing	0.01	0.01	0.01	0.01	0.02	0.04	0.23	0	0.05	0	0	0.01
array	0	0.01	0.01	0.01	0.02	0.08	0.23	0.01	0.04	0.07	0	0.06
multiple access scheme	0.03	0.01	0.01	0.02	0.01	0.02	0.23	0.01	0.01	0.02	0	0.01
perfect power control	0.01	0.02	0	0	0.02	0.03	0.22	0.05	0.09	0.03	0.01	0.02
diversity gain	0.02	0.01	0.02	0.02	0.01	0.05	0.22	0.02	0.05	0	0.01	0.04
modifications	0.07	0.03	0.03	0.01	0.03	0.03	0.22	0.11	0.05	0	0.01	0.01
gain	0.01	0	0.02	0.02	0.01	0.01	0.21	0.02	0.02	0.03	0	0.01
RAKE receiver	0.01	0.01	0	0.01	0.01	0.04	0.21	0.01	0.06	0.06	0.01	0.03
low power	0.03	0.02	0	0.02	0.04	0.07	0.2	0.12	0.02	0.05	0.03	0.05
satellite diversity	0.03	0.02	0.05	0.02	0.02	0.02	0.08	0.38	0.04	0.01	0.07	0.01
path loss	0.01	0.02	0.05	0.02	0.01	0.05	0.02	0.37	0.26	0.04	0.02	0.04
signals	0.06	0.03	0.04	0.19	0.16	0.04	0.01	0.29	0.01	0	0.05	0.05
communications	0.03	0.01	0.01	0.03	0.01	0.01	0.06	0.29	0.03	0.03	0	0.02
transmission quality	0	0.02	0.03	0.04	0.04	0.07	0.05	0.26	0.01	0.04	0.02	0.04
ALOHA	0.01	0.01	0.03	0.01	0	0.02	0.03	0.26	0	0.03	0.04	0.06
system	0.09	0.02	0.04	0.02	0.04	0.08	0.03	0.25	0.04	0.04	0.01	0.15
propagation	0.01	0.02	0.01	0	0.02	0.02	0.01	0.24	0.03	0	0	0.02
cochannel interference	0.01	0.02	0.02	0.02	0.06	0.02	0.02	0.24	0.03	0.01	0.01	0.06
voice communications	0.04	0.02	0.02	0.01	0.01	0.04	0	0.24	0.04	0.04	0.02	0.07
function	0.04	0.01	0.06	0.04	0.09	0.01	0.07	0.23	0.01	0.02	0.01	0.04
energy efficiency	0.01	0.03	0.03	0.01	0.06	0.02	0.03	0.22	0.04	0.02	0.01	0.06
broadcast	0.03	0	0.02	0.02	0.02	0.04	0.01	0.22	0	0.05	0.01	0.12
GSM	0.05	0.03	0.02	0.04	0.05	0	0.04	0.21	0.06	0.02	0.04	0
TDMA	0.07	0.03	0.03	0.02	0.02	0.01	0.04	0.02	0.49	0.05	0.01	0.04
multiple access interference MAI	0.01	0.01	0	0.01	0.02	0.08	0	0.01	0.37	0.01	0	0.04
multimedia traffic	0.05	0.01	0.01	0.04	0.02	0.02	0.01	0.03	0.37	0.1	0.03	0
TD-CDMA	0.02	0.01	0.01	0.01	0.01	0.05	0.03	0	0.35	0.06	0.01	0
multicast tree	0.03	0.04	0.07	0.03	0.04	0.03	0.01	0.03	0.34	0.06	0.05	0.06
multiple access	0.01	0.05	0.05	0.05	0.01	0.01	0.1	0.09	0.33	0.02	0.03	0.04
independent	0.01	0.01	0	0	0.02	0	0.01	0.02	0.28	0.03	0.02	0.04
rayleigh	0.02	0	0.01	0.07	0.03	0.02	0.03	0.07	0.28	0.02	0	0.03
heavy traffic	0.01	0.04	0.01	0	0.03	0.02	0.04	0.01	0.26	0	0.02	0.01
cell search	0.01	0.01	0	0.01	0	0.09	0.06	0.03	0.26	0.01	0.01	0.03
coherent Rake combining	0.04	0.03	0.03	0.01	0	0.03	0.05	0.04	0.26	0.02	0.02	0.02

calls	0.02	0.02	0.01	0.02	0.01	0.02	0.06	0.07	0.25	0.02	0.02	0.05
proposed scheme	0.03	0.01	0.01	0.15	0.1	0.02	0.02	0.09	0.24	0.08	0.02	0.09
analytical results	0.01	0.01	0	0.04	0.01	0.02	0.05	0.02	0.23	0.01	0	0.02
CSMA/CA	0.04	0.02	0.03	0.02	0.01	0.01	0.01	0.03	0.23	0.08	0.01	0.05
environments	0.03	0.01	0.01	0.04	0.01	0.02	0.02	0.08	0.22	0.05	0.02	0.02
mobile unit	0.02	0.01	0.03	0.05	0.01	0.02	0.04	0.12	0.22	0	0	0.03
connection	0.05	0.03	0.04	0.01	0	0.05	0	0.15	0.22	0.02	0.04	0.01
topology changes	0.01	0.01	0.01	0.04	0.03	0.06	0.14	0.01	0.21	0.01	0.01	0.05
network resources	0.02	0	0.02	0.01	0	0.04	0.01	0.02	0.05	0.43	0.05	0.13
resources	0.03	0.01	0.01	0.02	0.04	0	0.04	0.01	0.04	0.36	0.03	0.01
proposed algorithm	0.03	0.01	0.02	0.06	0.06	0.11	0.01	0.07	0.05	0.36	0	0.04
burst errors	0.05	0.01	0.01	0.07	0.07	0.09	0	0.04	0.09	0.36	0.01	0.02
multipath	0.02	0	0.01	0.03	0.02	0.05	0	0.04	0.06	0.26	0.01	0.01
channel	0.1	0	0.01	0.02	0.01	0.06	0.03	0.08	0.02	0.25	0.04	0.15
same time	0.04	0.01	0.01	0.04	0.01	0.03	0.06	0.05	0.01	0.25	0.04	0.06
user capacity	0.01	0.01	0.01	0.1	0.05	0.03	0.08	0.02	0.05	0.25	0	0.03
system design	0.01	0	0.02	0.01	0.02	0.06	0.02	0.04	0.03	0.25	0.02	0.02
cellular phones	0.04	0.02	0.03	0.13	0.1	0.18	0.03	0.08	0.03	0.24	0.01	0.09
transmission efficiency	0.03	0	0.01	0.07	0.06	0.08	0.09	0.05	0.02	0.22	0.02	0.15
channel throughput	0.05	0.01	0.02	0	0.02	0.03	0.02	0.06	0.03	0.22	0.04	0.04
mathematical analysis	0	0.01	0.02	0.02	0.01	0.04	0.05	0.01	0.04	0.21	0	0.02
bandwidth efficiency	0.02	0.02	0.08	0.12	0.08	0.06	0.01	0.01	0.02	0.21	0.06	0.06
proposed MAC protocol	0.01	0.01	0.01	0.05	0.02	0.04	0.01	0.02	0.09	0.2	0.01	0.13
throughput	0.06	0.01	0.01	0.07	0.06	0.01	0.05	0.06	0.04	0.2	0.01	0.11
CDMA mobile system	0.1	0	0	0.06	0.02	0.03	0.01	0	0	0.2	0.03	0.03
bandwidth allocation	0.09	0.02	0.15	0.02	0.01	0.01	0.03	0.01	0.03	0.02	0.24	0.22
time slots	0.02	0.12	0.13	0.05	0.01	0.05	0.07	0.04	0	0.08	0.22	0.06
required QoS	0.05	0.01	0.19	0.02	0	0.02	0	0	0.02	0.02	0.21	0.05
adaptive antennas	0.02	0.01	0.04	0.02	0.02	0.07	0.01	0	0.02	0.13	0.01	0.33
capture	0.02	0.02	0.03	0.06	0.03	0.14	0.01	0	0.01	0.08	0.02	0.32
MC-CDMA system	0.03	0.01	0.01	0.04	0.06	0.03	0.04	0.02	0.03	0.04	0.03	0.27
mobile users	0.09	0.02	0.03	0.06	0.02	0.17	0.03	0.07	0.03	0	0.05	0.26
MAC protocol	0.07	0	0.12	0.04	0.01	0.08	0.05	0.19	0.07	0.06	0.08	0.23
infrastructure	0.16	0.08	0.06	0	0.06	0.01	0.03	0.14	0.06	0.06	0.09	0.2
radio systems	0.08	0	0.02	0.04	0	0.03	0.03	0.09	0.09	0.19	0.03	0.19
wireless network	0.06	0.02	0.04	0.03	0.16	0.07	0.1	0.07	0.08	0.01	0.03	0.19
wireless ATM network	0	0.03	0	0.09	0.03	0.02	0.16	0.04	0.07	0.17	0.03	0.18
wireless communication systems	0.02	0	0.18	0.08	0.03	0.03	0.01	0.03	0.02	0.01	0.19	0.18
codes	0.09	0.09	0.08	0.04	0.01	0.13	0.01	0.08	0	0.03	0.05	0.18
personal communication systems	0.1	0.01	0	0.03	0.03	0.16	0.01	0.03	0.03	0.12	0.05	0.18
ATM cell	0.08	0.02	0.05	0.04	0	0.04	0.01	0.14	0.02	0.05	0.08	0.17
connections	0.01	0.01	0.02	0.06	0.06	0.04	0.07	0.03	0	0.16	0	0.17
wireless systems	0.08	0.05	0.02	0.04	0.01	0.12	0.07	0.01	0.06	0.01	0	0.17
resource allocation	0.01	0.01	0.12	0.04	0	0	0.02	0.02	0.02	0.01	0.13	0.16
data transmission	0.08	0	0.1	0.08	0.1	0.04	0.05	0.05	0.05	0.01	0.09	0.16
local area networks	0.07	0.01	0.2	0.05	0.02	0.03	0.08	0.04	0.02	0.17	0.16	0.16
equilibrium point analysis	0.19	0.01	0.01	0.03	0.11	0.01	0.05	0.01	0.05	0.05	0.07	0.16
code-division multiple access CDMA	0.05	0	0.01	0.03	0	0.12	0.02	0.01	0.01	0.08	0.05	0.16
fading channels	0.05	0.01	0.03	0.02	0.1	0.06	0.04	0.06	0.1	0.07	0.03	0.16
system parameters	0.05	0.01	0.02	0.01	0.01	0.01	0.04	0.1	0.01	0.04	0	0.15
performance analysis	0.09	0.05	0.08	0.03	0	0.06	0	0.07	0	0.06	0.12	0.15
base station BS	0.02	0.01	0.03	0.03	0	0.11	0.05	0.06	0.02	0.04	0.01	0.15
WLAN	0.04	0	0.02	0.01	0.03	0.07	0.01	0.03	0.02	0.04	0.13	0.13
channel errors	0.09	0.02	0.04	0	0.03	0.04	0.01	0.05	0.03	0.03	0.08	0.13
FEC	0.02	0	0.01	0	0.01	0.04	0.02	0.04	0.03	0.01	0.01	0.13
LANs	0.09	0.01	0	0.03	0.09	0.03	0	0.01	0	0.01	0.01	0.13
amplifiers	0.09	0.01	0.12	0.06	0.07	0.01	0.03	0.03	0.02	0.01	0.1	0.13
structure	0.03	0	0.07	0.01	0.02	0.03	0.01	0.03	0.05	0.03	0.08	0.13
Uplink channels	0.05	0.01	0.01	0.02	0.03	0.05	0.01	0.03	0.02	0.04	0.03	0.13
implementation complexity	0.01	0.01	0.02	0.14	0.13	0.06	0.02	0.03	0	0.14	0.03	0.13
data services	0.04	0	0.02	0.05	0.07	0.01	0	0.04	0.03	0.01	0.01	0.13
field experiments	0.01	0.01	0.08	0.01	0.02	0.02	0.03	0.06	0.02	0	0.13	0.12
blocking probabilities	0.06	0.03	0.01	0.12	0.08	0.03	0.04	0.07	0.04	0.12	0.01	0.12
transmission medium	0.06	0.11	0.11	0.03	0.07	0.19	0.1	0.09	0.02	0.02	0.12	0.12
Rayleigh fading channel	0.16	0.03	0.01	0.02	0.04	0	0.03	0.01	0.01	0.02	0.02	0.12
fast TPC	0.13	0.02	0.01	0.03	0.18	0.03	0.03	0.01	0.1	0.01	0.05	0.12
station	0.03	0	0.02	0.01	0.01	0	0	0.02	0.01	0.01	0.01	0.12
Rake receivers	0.19	0.02	0	0.02	0.06	0.02	0.01	0.01	0	0.01	0.01	0.11
CBR	0.02	0	0.01	0.1	0.04	0	0.03	0.03	0.06	0.06	0.01	0.11
ATM networks	0.13	0.01	0.07	0.13	0.1	0.04	0.02	0.07	0.11	0.01	0.03	0.11
radio interface	0.07	0.02	0.01	0.04	0.06	0.13	0.01	0.01	0	0.13	0.04	0.1
low complexity	0.06	0	0.02	0.02	0.02	0.04	0.02	0.09	0	0.02	0.01	0.1
BPSK	0.03	0.04	0.1	0.02	0.04	0.02	0.02	0.02	0.04	0.01	0.1	0.1
real time	0.01	0.02	0.01	0.1	0.09	0.07	0.05	0.06	0.12	0.13	0.03	0.1

face	0.02	0.01	0.01	0.08	0.05	0.02	0.03	0.04	0.01	0.08	0.02	0.1
delay spread	0.03	0.01	0	0.02	0.01	0	0.03	0.01	0.05	0.04	0.02	0.1
ETSI	0.01	0	0	0	0	0.02	0	0	0.01	0.12	0.01	0.1
radio channel	0.03	0	0.13	0.04	0	0	0.03	0.03	0.02	0.01	0.11	0.1
fast fading	0.03	0.02	0.01	0.05	0	0.02	0.02	0.07	0.07	0.18	0.01	0.1
diversity reception	0.14	0.01	0	0.05	0.04	0.03	0.01	0.01	0	0.01	0.02	0.1
differential phase shift	0.08	0	0.08	0.02	0.03	0.02	0.01	0.04	0.01	0.01	0.1	0.09
bit error probability	0.12	0.02	0.02	0.02	0	0.01	0.01	0.04	0.01	0.01	0.05	0.09
hidden terminals	0.06	0.01	0	0	0.02	0.03	0.1	0.04	0.04	0.07	0	0.09
circuit	0.03	0.03	0.04	0.02	0.01	0.01	0.03	0.03	0.02	0.01	0.1	0.09
high throughput	0.04	0.01	0.08	0.02	0.03	0.02	0.04	0.03	0.02	0.03	0.09	0.09
stations	0.1	0.01	0.01	0.03	0.02	0	0	0	0.03	0	0.02	0.09
interference power	0.05	0	0	0	0.04	0.02	0.13	0.01	0.02	0.05	0.02	0.09
CMS	0.04	0.01	0.01	0.06	0.11	0.02	0	0.04	0.11	0.01	0.03	0.09
communication	0.05	0.01	0.01	0.06	0.05	0.02	0.04	0.03	0.01	0.02	0.02	0.09
jamming	0.2	0.01	0.01	0.11	0.12	0.03	0.01	0.07	0.02	0.02	0.02	0.09
ATM connections	0.08	0.07	0.03	0.03	0.16	0.06	0.09	0.06	0.14	0.01	0.02	0.09
spreading codes	0.03	0.01	0	0.01	0.01	0.01	0.16	0.03	0.08	0.01	0	0.09
multiuser interference MUI	0.01	0	0	0.02	0.01	0.01	0.07	0.06	0.01	0.15	0.02	0.09
UDP	0.01	0	0.01	0.01	0.02	0.05	0.01	0.02	0.06	0.02	0.02	0.09
QPSK	0.07	0.02	0.04	0.02	0.05	0.04	0.04	0.05	0.02	0.13	0	0.09
data communications	0.14	0	0.04	0.01	0.02	0.01	0	0.01	0	0.02	0.07	0.09
call control	0.02	0.04	0.07	0.01	0.02	0.13	0.05	0.02	0.02	0.01	0.03	0.08
selection diversity	0.13	0.02	0.14	0.06	0.04	0	0.02	0.03	0.03	0	0.13	0.08
mobile ad hoc networks	0.07	0	0.01	0.02	0.07	0.13	0.12	0.04	0.06	0.06	0.02	0.08
personal Communications Services PCS	0.03	0	0	0	0.01	0.02	0	0.02	0.02	0	0	0.08
numerical results	0.14	0.02	0.08	0.02	0.03	0.01	0	0.01	0.02	0.02	0.07	0.08
mobile nodes	0.01	0.03	0.07	0.01	0.01	0.1	0.05	0.03	0.02	0.03	0.03	0.08
ARQ protocol	0.01	0	0.01	0.03	0.03	0.02	0.01	0.04	0.02	0.02	0.02	0.08
Hiperlan/2	0.09	0.02	0.01	0.01	0	0.01	0.02	0.01	0.02	0	0.01	0.08
signal	0.07	0.02	0.02	0.03	0.03	0.19	0.04	0.03	0.03	0.01	0.01	0.08
broadband services	0.07	0.02	0.1	0.08	0.07	0.18	0.11	0.02	0.09	0.07	0.06	0.08
transmissions	0.12	0.02	0.05	0.07	0.08	0.01	0.01	0.05	0.02	0.1	0.05	0.08
bit error rate performance	0.08	0.02	0.02	0.01	0.01	0.11	0.03	0.08	0.05	0.05	0.02	0.08
IEEE 802.11	0.02	0.01	0.01	0.03	0	0.02	0.03	0.07	0.01	0.05	0.03	0.08
channel estimation errors	0.02	0	0.01	0.01	0.01	0.02	0.02	0.01	0.03	0.04	0.02	0.08
transmission	0.02	0	0.01	0.02	0.04	0.07	0.02	0.07	0.02	0.02	0.02	0.08
QPSK modulation	0.06	0.03	0.08	0.02	0	0.03	0.04	0.03	0.09	0.02	0.06	0.08
MAI	0.06	0	0.01	0.05	0.01	0.14	0.1	0.05	0.04	0.12	0.01	0.08
Service QoS	0.03	0.01	0.01	0.02	0.03	0.14	0.07	0.06	0.02	0.17	0	0.08
wireless ATM	0.11	0	0.01	0.02	0.07	0.01	0.01	0.02	0.01	0.02	0.02	0.07
data terminals	0.04	0.01	0.03	0.04	0.03	0.02	0.01	0.05	0.02	0	0.04	0.07
voice terminals	0.03	0	0.01	0.02	0.03	0.07	0.05	0.06	0.02	0.07	0.01	0.07
voice packets	0.11	0	0	0.01	0.03	0.03	0	0.02	0.01	0.01	0	0.07
functions	0.06	0.04	0.08	0.01	0.02	0.12	0.07	0.15	0.07	0.01	0.04	0.07
multipath fading channels	0.04	0.01	0.04	0.04	0	0.01	0.04	0.04	0.03	0.04	0.04	0.07
computational complexity	0.08	0.01	0.01	0.02	0	0.04	0.09	0	0.01	0.04	0.01	0.07
Data link	0.05	0	0.01	0.12	0.14	0.02	0.02	0.04	0.03	0.05	0.01	0.07
topology	0.02	0.01	0	0.02	0.01	0.09	0.17	0.02	0	0.02	0.01	0.07
signal-to-noise ratio	0.18	0.01	0.02	0.04	0	0.01	0.04	0	0.01	0.08	0.02	0.07
efficiency	0.04	0.01	0.01	0.03	0.02	0.03	0.01	0.02	0	0	0.02	0.07
authentication	0.02	0.01	0.02	0.03	0.09	0.03	0	0.03	0.01	0	0.02	0.07
OFDM	0.05	0	0	0.03	0.05	0.02	0.01	0.03	0	0.03	0.02	0.07
bandwidth	0.01	0	0.03	0.02	0.02	0	0.01	0.04	0.01	0.03	0	0.07
simulation results	0.03	0	0.14	0.05	0.05	0.02	0.05	0.02	0.03	0.04	0.16	0.07
wired	0.03	0	0.07	0	0.01	0	0.01	0.04	0.02	0.02	0.09	0.07
power consumption	0.09	0.01	0.01	0.03	0.01	0.01	0.02	0.03	0.01	0.03	0.01	0.07
bit rate	0	0	0.01	0.01	0.04	0	0.02	0.01	0.02	0	0.02	0.07
ATM Forum	0.04	0	0.02	0.02	0.02	0.01	0.07	0.08	0.05	0.17	0	0.07
wireless environment	0.13	0.02	0.03	0.02	0.02	0.01	0.04	0.02	0.04	0.06	0.03	0.06
channel state	0.12	0	0.01	0.15	0.12	0	0.03	0.05	0.07	0.07	0.01	0.06
performance results	0.06	0.01	0.02	0.02	0.01	0.04	0.03	0.03	0.05	0.07	0.01	0.06
transmission time	0.01	0	0.01	0.06	0.03	0.03	0.02	0.04	0.07	0.15	0.03	0.06
wireless LAN applications	0.04	0	0	0	0.03	0.02	0.01	0.02	0.01	0	0	0.06
indoor environment	0	0.05	0.16	0.15	0.07	0.07	0	0.01	0.01	0.11	0.14	0.06
links	0.03	0.03	0.04	0	0.03	0.01	0.05	0.01	0.07	0.13	0.03	0.06
adaptive antenna array	0.01	0.02	0	0.02	0.08	0.02	0.05	0	0.05	0.01	0.01	0.06
performance degradation	0.01	0.01	0	0.01	0.06	0	0.01	0	0.09	0.02	0.03	0.06
2.4 GHz	0.02	0.02	0.03	0	0	0.04	0	0	0.01	0.03	0.02	0.06
new protocol	0.14	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0	0.01	0.06
simulation environment	0.01	0.01	0.08	0.02	0.02	0.05	0.04	0.07	0.1	0.14	0.07	0.06
medium access control MAC protocol	0.06	0.01	0	0.04	0.02	0	0.03	0.01	0.01	0.02	0.03	0.06
indoor channel	0.03	0.04	0	0.01	0.04	0.03	0.02	0.18	0.02	0	0.01	0.06
bit error rate BER	0.08	0.01	0.01	0.01	0.04	0.01	0	0	0.01	0.02	0.01	0.06

battery	0.01	0	0	0.07	0.12	0.04	0.02	0.02	0.01	0.07	0.01	0.06
energy consumption	0.03	0.01	0.01	0.01	0.01	0.03	0	0.01	0.19	0.02	0.01	0.06
channels	0.02	0.01	0.01	0.02	0.04	0.01	0.03	0.03	0.02	0.03	0.03	0.06
WATM	0.17	0	0.01	0.03	0	0.04	0.02	0.02	0.06	0.02	0.02	0.06
intersymbol interference ISI	0.04	0	0.05	0.03	0	0	0.03	0	0.01	0.01	0.04	0.06
Mobile IP	0.02	0.01	0.02	0.02	0.03	0.01	0.03	0	0.01	0.03	0.02	0.06
access	0.02	0	0.02	0.01	0.01	0.02	0.05	0.07	0.04	0.03	0.02	0.06
integration	0.02	0.03	0.01	0.04	0.03	0.02	0.04	0.01	0.05	0.01	0.01	0.06
ATM cells	0.13	0.01	0.01	0.2	0.13	0.02	0.01	0.01	0.01	0.01	0.01	0.06
numerical examples	0.04	0.01	0.19	0	0.02	0.01	0.01	0.04	0.01	0.04	0.17	0.06
HIPERLAN	0.03	0.05	0.05	0.04	0.01	0	0.01	0.08	0.08	0.14	0.06	0.06
Ipv6	0.01	0.02	0	0.01	0.01	0.02	0.01	0.04	0.02	0.04	0.04	0.06
channel characteristics	0.08	0	0.01	0	0.02	0.02	0.03	0.01	0.01	0.03	0.02	0.06
AWGN	0.06	0.01	0.03	0.01	0.01	0.02	0.05	0.02	0.02	0.03	0.06	0.06
training sequences	0.03	0	0	0.01	0.03	0.03	0.12	0.01	0.01	0.08	0.02	0.05
frequency selectivity	0.08	0.03	0.03	0.01	0.1	0.03	0.05	0.12	0.02	0.04	0.02	0.05
EDGE	0.06	0.02	0.11	0.04	0.01	0.13	0.06	0.01	0.03	0.02	0.07	0.05
multipath dispersion	0.08	0.01	0.01	0.01	0.04	0.01	0.02	0.03	0.02	0.03	0.01	0.05
Rake combiner	0.05	0.01	0.04	0.05	0.04	0.02	0.03	0.01	0.05	0.01	0	0.05
code division multiple access CDMA syst	0.15	0.01	0.11	0.05	0	0.02	0.04	0.04	0.05	0.04	0.1	0.05
computer simulation results	0.02	0.02	0.04	0.08	0.04	0.05	0.03	0.02	0.06	0.06	0.01	0.05
multicarrier modulation	0.01	0.02	0.01	0.04	0.04	0.03	0.01	0.01	0.18	0.02	0	0.05
wireless local area networks	0.1	0.03	0.07	0.02	0.01	0.03	0	0.02	0.02	0.02	0.09	0.05
IC	0.03	0.02	0.04	0.18	0.15	0.04	0.01	0.03	0	0.07	0.03	0.05
VER	0.07	0.02	0.04	0.06	0.03	0.04	0.04	0.09	0.13	0.03	0.02	0.05
CSMA/CD protocol	0.09	0.02	0.01	0.01	0	0.01	0.04	0.04	0.05	0.05	0.02	0.05
cellular mobile radio systems	0.13	0	0	0.01	0.03	0	0.02	0.02	0.03	0.04	0.01	0.05
control	0.05	0.01	0.01	0.05	0.03	0.03	0.01	0.06	0.08	0.04	0	0.05
parameters	0.06	0.01	0.03	0.01	0.01	0.03	0.01	0.02	0.01	0.03	0.01	0.05
space diversity	0.02	0	0.02	0.01	0.02	0.02	0	0.02	0.03	0.01	0.01	0.05
antenna diversity	0.01	0.07	0	0.07	0.09	0.16	0	0.01	0.02	0.01	0.06	0.05
data rates	0.09	0.01	0.06	0.08	0.12	0.04	0.06	0.04	0.03	0.09	0.05	0.05
orthogonal frequency-division multiplexin	0.04	0	0.01	0.06	0.05	0.03	0.01	0.08	0.13	0.01	0.02	0.05
filters	0.11	0	0.01	0	0.02	0.02	0.02	0.01	0.03	0.01	0	0.05
Universal Mobile Telecommunications Sy	0.05	0.03	0.02	0.03	0	0.01	0.02	0	0.03	0.05	0	0.05
Forward Error Correction FEC	0.03	0.1	0.05	0	0.01	0.09	0.12	0.11	0	0.11	0.07	0.05
DCF	0.02	0.01	0.07	0.05	0.03	0.02	0.01	0.01	0.03	0.02	0.06	0.05
supply voltage	0.01	0.01	0.01	0.04	0.02	0.01	0.06	0.07	0.01	0.09	0	0.05
wireless local-area networks WLANs	0.03	0.03	0.02	0.02	0.02	0.03	0	0.03	0.06	0.07	0	0.05
mobile hosts	0.05	0.02	0	0.07	0.02	0.03	0.09	0.11	0.03	0.19	0.02	0.05
joint detection	0	0.01	0.04	0.01	0.03	0.05	0.01	0.1	0	0.02	0.05	0.05
multimedia	0.08	0	0	0.01	0.02	0.03	0.01	0.03	0.03	0.03	0.04	0.05
data rate	0	0.01	0.04	0.01	0.01	0.05	0.03	0.02	0.02	0.05	0.02	0.05
synchronisation	0.07	0.01	0.02	0.05	0.01	0.05	0.02	0.05	0.11	0.05	0.01	0.05
portable terminals	0.02	0.01	0.01	0.02	0.04	0.01	0.01	0.13	0.02	0	0.01	0.05
protocol	0.08	0.02	0.02	0.05	0.02	0.02	0.04	0.03	0.02	0.02	0.01	0.05
wireless LANs	0	0.01	0.02	0.01	0.01	0.03	0.06	0.01	0.05	0.07	0.01	0.05
frequency offset	0.08	0.04	0.05	0.02	0.02	0.03	0.06	0.02	0.03	0.04	0	0.05
Synchronization	0.02	0.01	0.03	0.01	0.01	0.1	0.03	0.02	0.02	0.01	0	0.05
integrated voice	0.02	0.01	0.01	0.01	0.03	0.03	0	0.08	0.02	0	0	0.05
estimation	0.01	0	0	0.02	0.03	0.06	0.14	0.02	0.01	0.03	0.01	0.04
partitioning	0.01	0.01	0.02	0.02	0.01	0.04	0.01	0.13	0.01	0.01	0.01	0.04
channel fading	0.01	0	0.05	0	0.02	0.03	0.02	0.17	0.03	0.05	0.01	0.04
cell loss	0.18	0.01	0.01	0.04	0.04	0.01	0	0.01	0.03	0.03	0.02	0.04
mobile computers	0.11	0	0.01	0.17	0.13	0.01	0	0.04	0.09	0	0.02	0.04
DS-CDMA mobile radio	0.03	0.01	0.03	0.01	0.04	0.04	0.19	0.04	0.01	0.01	0.01	0.04
reliable communication	0.16	0.01	0.01	0.03	0.06	0.02	0.03	0.05	0	0.02	0.05	0.04
consideration	0.04	0.02	0.01	0.05	0.02	0.04	0.07	0.16	0.03	0.04	0.03	0.04
wireless ATM systems	0.02	0	0	0.04	0.01	0.04	0.09	0.04	0.12	0.09	0.02	0.04
delay performance	0.13	0.07	0.03	0.01	0	0.02	0	0.03	0.08	0.02	0.01	0.04
wireless networks	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.04
Handover	0.01	0.03	0.02	0.01	0.03	0.05	0.08	0.18	0.05	0.01	0	0.04
data traffic	0	0.01	0	0.02	0.03	0.02	0.03	0.03	0.03	0.06	0.03	0.04
network architecture	0.02	0.01	0.01	0.02	0	0.09	0.06	0.07	0.05	0	0.02	0.04
transmission errors	0	0.1	0.01	0.07	0.06	0.02	0	0.03	0.02	0.05	0.02	0.04
IEEE 802.11 MAC protocol	0.01	0.01	0.01	0.02	0.02	0.04	0.06	0.02	0.07	0.01	0.02	0.04
TCP performance	0.03	0.01	0	0.03	0.01	0	0.01	0.06	0.03	0.09	0.02	0.04
router	0.05	0.01	0.01	0	0.01	0	0.03	0	0.01	0.03	0.02	0.04
Ethernet	0.05	0	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.04	0.02	0.04
IEEE 802.11 standard	0.04	0.03	0.01	0.03	0.02	0.03	0.06	0.06	0.03	0.03	0.01	0.04
TCP/IP	0.04	0.02	0.02	0.02	0.01	0.02	0.02	0.01	0.03	0.05	0.01	0.04
mechanism	0.08	0.02	0.01	0.02	0.01	0.02	0	0.02	0.01	0.02	0	0.04
voice traffic	0.01	0.02	0.01	0.02	0.04	0.01	0.02	0.12	0.03	0.04	0	0.04
DS-CDMA systems	0.03	0.01	0.01	0.02	0.02	0.03	0.01	0.17	0.01	0.03	0	0.04

ATM network	0.04	0.01	0.01	0.02	0.01	0.01	0.02	0.09	0.01	0.05	0.02	0.04
orthogonal frequency division multiplexing	0.1	0	0.03	0.02	0.02	0.04	0.02	0	0.01	0.1	0.01	0.04
radio resources	0.04	0.01	0.01	0.02	0	0.05	0.04	0	0.01	0.17	0.01	0.04
chip rate	0.03	0.02	0.01	0.02	0.04	0.06	0	0.11	0.09	0.04	0.01	0.04
wide range	0	0.01	0.01	0.11	0.09	0.04	0.02	0.03	0.02	0.07	0	0.04
IP	0.03	0.01	0	0.07	0.06	0.06	0.02	0.05	0.03	0.02	0.03	0.04
packet size	0.07	0	0.04	0.03	0.01	0.01	0	0.02	0.02	0.02	0.03	0.04
MAC protocols	0.08	0.02	0.05	0.04	0.05	0.07	0.05	0.15	0.04	0.01	0.03	0.04
throughput-delay performance	0.06	0.05	0.03	0.03	0.02	0	0.05	0.15	0.02	0	0.03	0.04
transmission rates	0.01	0.01	0	0.01	0.01	0.01	0.03	0.06	0.02	0.07	0.03	0.04
impulse response	0	0.01	0	0.02	0	0.01	0.08	0.01	0	0.04	0.02	0.04
information	0.04	0.01	0	0.01	0.01	0	0.03	0.01	0.01	0.03	0.01	0.04
spread spectrum	0.12	0.01	0.01	0.02	0.04	0.01	0.01	0.03	0.01	0.02	0	0.04
talkspurt	0	0.01	0	0.03	0	0	0.02	0.02	0.03	0.07	0.03	0.04
ARQ	0.04	0.01	0.02	0.07	0.05	0	0.01	0.05	0	0.06	0.01	0.04
degradation	0.1	0.02	0.03	0.1	0.1	0.04	0.2	0.01	0.09	0.04	0	0.04
random access protocol	0.07	0.01	0.01	0.03	0.01	0.04	0.03	0.04	0.03	0.11	0.05	0.04
data transmissions	0.06	0.02	0.05	0.01	0.09	0.02	0	0.05	0.01	0.01	0.05	0.04
transceiver	0.06	0.01	0.01	0.03	0.01	0.02	0.04	0.03	0.03	0.07	0.03	0.04
software	0.04	0	0	0.03	0.01	0.01	0.02	0.03	0	0.03	0.03	0.04
surface acoustic wave	0.04	0.02	0.02	0.03	0.01	0	0.01	0.09	0.03	0.02	0.02	0.04
traffic performance	0.02	0	0.02	0.01	0.02	0.01	0.01	0	0.02	0.02	0.01	0.04
transmission power	0.05	0.01	0.01	0.01	0	0.01	0.02	0.02	0.01	0.01	0.01	0.04
point	0.04	0	0.01	0.01	0.02	0	0	0.05	0.06	0.01	0.01	0.04
multipath channel	0.12	0.02	0.02	0.04	0.05	0.02	0.02	0.06	0.01	0.04	0.03	0.04
medium access control protocol	0	0.01	0.05	0.01	0.03	0.01	0.04	0.14	0.04	0	0.03	0.04
node	0.08	0	0.03	0.04	0.02	0.1	0.01	0.01	0.07	0.06	0.02	0.04
wireless local area networks WLANs	0.05	0.01	0.01	0.04	0.03	0.07	0	0.05	0.04	0.09	0.02	0.04
video	0.04	0.02	0.01	0.01	0.02	0.03	0.02	0	0.02	0.04	0.02	0.04
network architectures	0.02	0.01	0	0.03	0.01	0.02	0	0.06	0.01	0.01	0.02	0.04
ad hoc network	0.07	0.01	0.03	0.12	0.13	0.04	0.03	0.03	0.01	0.06	0.01	0.04
average BER	0	0.01	0.01	0.02	0.01	0	0.03	0.03	0	0.02	0.01	0.04
simulation	0.05	0.01	0.18	0.04	0.01	0	0.04	0.02	0.01	0.02	0.17	0.04
high capacity	0	0	0.08	0.02	0	0.01	0	0.03	0.01	0.03	0.05	0.04
wireless terminals	0.02	0	0.01	0.01	0.01	0.01	0.04	0.15	0.05	0.02	0.01	0.04
system architecture	0.02	0.01	0.02	0.13	0.12	0.02	0	0.05	0.03	0.01	0.01	0.04
low bandwidth	0.01	0.01	0.01	0.01	0.01	0.07	0.07	0.05	0.02	0.04	0.01	0.04
E-b/N-0	0.03	0.01	0	0.03	0.03	0.01	0.01	0.01	0.01	0.01	0.03	0.03
mechanisms	0.09	0.06	0.02	0.03	0.03	0.01	0.05	0.01	0.1	0.01	0.02	0.03
carrier sense multiple access	0.01	0.01	0	0.03	0.03	0	0.01	0.06	0.1	0.02	0.02	0.03
seamless integration	0.01	0	0	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.03
wireless application protocol WAP	0.02	0.01	0.03	0	0.03	0.05	0.01	0.11	0.02	0.02	0.01	0.03
on-demand	0.01	0.01	0	0	0.02	0	0.02	0.01	0.02	0.03	0.01	0.03
Service QoS requirements	0.06	0.01	0	0.1	0.04	0.01	0	0.01	0.02	0.02	0.03	0.03
networks	0.04	0.01	0.01	0.05	0.02	0	0.05	0.06	0	0.03	0.02	0.03
voice	0.01	0	0.02	0.01	0.01	0.08	0.04	0.04	0.08	0.01	0.02	0.03
range	0.01	0	0	0.03	0	0.03	0.02	0.04	0.04	0.17	0.02	0.03
filter	0.02	0.01	0	0.01	0	0.01	0.02	0.08	0.04	0.04	0.02	0.03
interfering signals	0.04	0	0.01	0.02	0.06	0	0.03	0.19	0.02	0.03	0.02	0.03
mobile devices	0.02	0.01	0	0.03	0.03	0.02	0.03	0.06	0.02	0.05	0.01	0.03
analytical framework	0.04	0.02	0.01	0	0.04	0	0.03	0.16	0.01	0.01	0.01	0.03
DS-CDMA	0.01	0.01	0.16	0.01	0	0	0	0.04	0.02	0.03	0.17	0.03
narrowband	0.04	0.02	0.01	0.02	0.01	0.02	0.03	0.07	0.02	0.18	0.01	0.03
interference suppression	0.06	0	0.01	0.1	0.07	0.03	0.01	0.07	0.07	0.03	0.01	0.03
PCS	0.03	0.01	0.01	0.01	0.02	0.03	0.08	0.03	0.1	0.09	0.02	0.03
noncoherent demodulation	0.04	0.02	0.04	0.05	0.04	0.1	0.04	0	0.1	0.06	0.06	0.03
mobile node	0.05	0.01	0.07	0	0.02	0.03	0.04	0.12	0.01	0.03	0.03	0.03
source	0.04	0.01	0	0	0.01	0.01	0.02	0.01	0	0.05	0.02	0.03
performance measures	0.04	0.01	0.02	0.01	0	0.01	0.06	0	0.14	0.01	0.02	0.03
multiuser detection	0.09	0.01	0.02	0.02	0.04	0.01	0.03	0.02	0.02	0.07	0.02	0.03
asynchronous transfer mode ATM	0.01	0.01	0.02	0.01	0.01	0.05	0.1	0.03	0.03	0.02	0.02	0.03
satellite	0.12	0.01	0.01	0.03	0.02	0	0	0.03	0.02	0.02	0.01	0.03
interference cancellation	0.03	0.02	0.01	0	0.02	0.08	0.15	0.03	0	0.06	0.01	0.03
spectral efficiency	0.04	0	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.04	0.01	0.03
channel state information	0.05	0.02	0.02	0.01	0.04	0.01	0.09	0.02	0.15	0.02	0.01	0.03
wireless links	0.01	0.05	0.01	0.01	0.02	0.01	0.02	0.13	0	0.01	0.01	0.03
collisions	0.09	0.01	0.01	0.09	0.06	0.01	0.03	0.05	0.05	0.02	0	0.03
radio	0.05	0.03	0.02	0.01	0.02	0.01	0	0.1	0.12	0.01	0	0.03
average bit error rate BER	0.03	0.01	0.06	0.01	0.01	0.02	0.13	0.01	0.05	0.13	0.04	0.03
wireless medium	0.04	0	0	0.02	0.04	0.07	0.14	0.05	0.02	0.04	0.02	0.03
UMTS	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.04	0.02	0.04	0.01	0.03
wireless Internet	0.05	0	0.13	0.02	0.04	0.01	0.04	0.01	0	0	0.11	0.03
noise	0	0.03	0.08	0.02	0.04	0.03	0.02	0.14	0.03	0.04	0.07	0.03

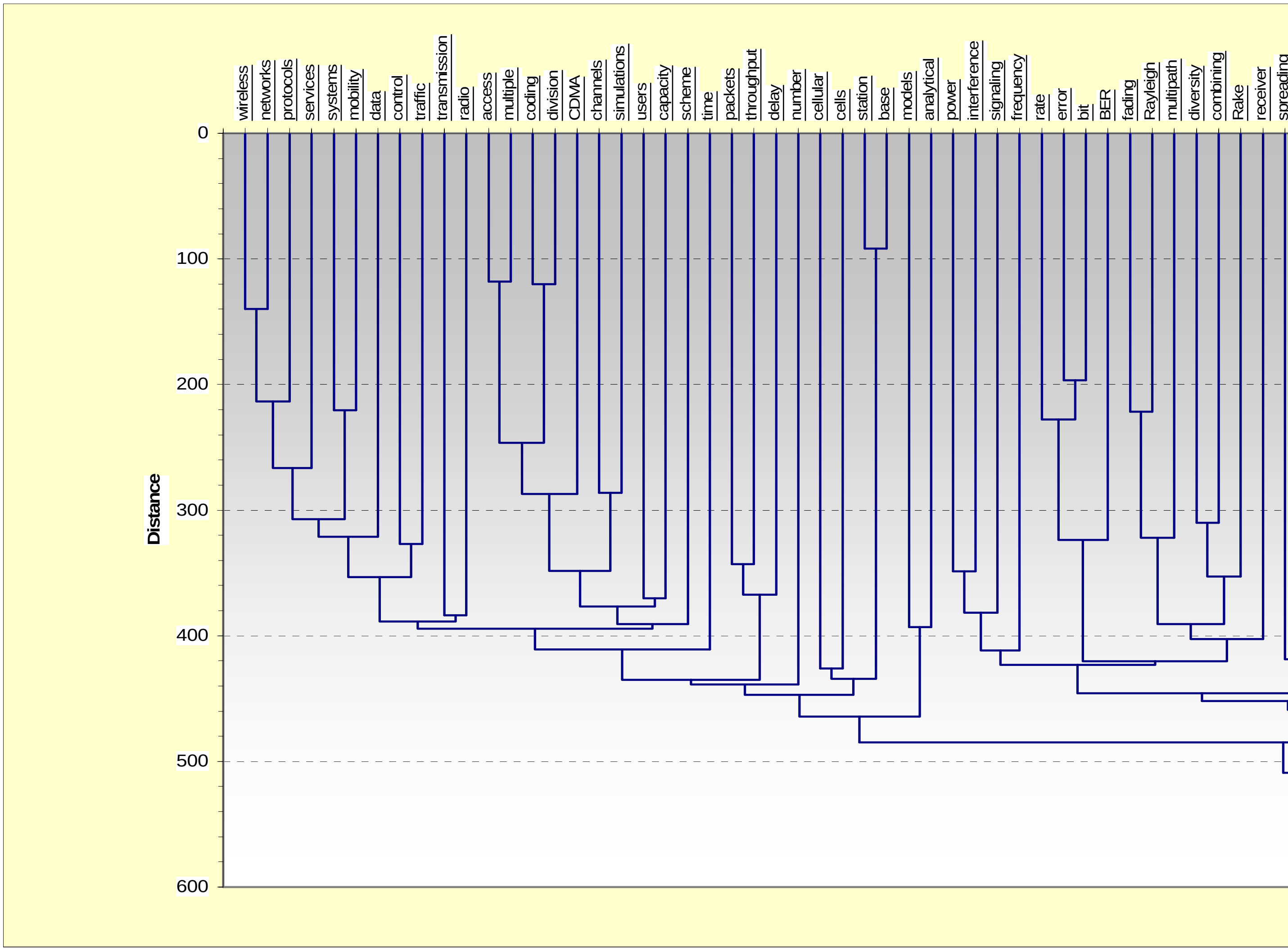
CSMA	0.02	0.01	0	0.01	0.02	0.02	0.09	0.01	0.01	0.01	0.02	0.03
mobile terminals	0.02	0.01	0.01	0.03	0.02	0.02	0.01	0.08	0.06	0.01	0.02	0.03
time	0.19	0	0	0.05	0.06	0	0.02	0	0	0.02	0.01	0.03
bursty errors	0.04	0.01	0	0.06	0.03	0.01	0.05	0.01	0.2	0.05	0	0.03
temperature	0.03	0.03	0.1	0.02	0.04	0.02	0.04	0.04	0.01	0.02	0.12	0.03
matched filter	0.02	0	0.01	0.01	0.03	0	0.04	0.09	0.01	0.11	0.04	0.03
multimedia services	0.06	0.01	0.01	0.01	0.01	0	0.01	0.01	0.03	0.02	0.02	0.03
simulations	0.1	0	0.01	0.02	0.02	0	0.03	0.01	0.01	0.05	0.01	0.03
clusters	0.01	0.01	0.03	0.05	0.01	0.01	0.08	0.02	0.1	0.07	0.01	0.03
IMT-2000	0.06	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.03	0.01	0.03
network nodes	0	0.01	0.01	0.02	0.03	0.01	0.02	0.05	0	0.03	0.01	0.03
ad hoc wireless networks	0.06	0.04	0.06	0	0.06	0.06	0.03	0.14	0.03	0.04	0.09	0.03
channel conditions	0.04	0.01	0.01	0.02	0	0.02	0.04	0.07	0.01	0.02	0.02	0.03
multiplexing	0.06	0.03	0.01	0.01	0	0.05	0.07	0.04	0.03	0.04	0.02	0.03
location management	0.04	0.01	0.03	0	0.01	0.1	0.06	0.05	0.01	0.07	0.02	0.03
standard	0.06	0	0.02	0.04	0.04	0.03	0.03	0	0.01	0.04	0.02	0.03
PDAs	0.01	0.05	0.05	0.02	0.02	0.02	0.07	0.08	0.01	0.02	0.02	0.03
channel estimation	0	0.01	0.01	0.02	0.01	0	0.03	0.02	0.01	0.04	0.01	0.03
channel capacity	0.04	0	0.01	0.08	0.06	0.03	0.01	0.06	0.08	0.05	0.01	0.03
W-CDMA	0.05	0	0.16	0.01	0.03	0.01	0.01	0.03	0.02	0.02	0.17	0.03
Bluetooth wireless technology	0.01	0.01	0.05	0.01	0.01	0	0.01	0.02	0.03	0.03	0.05	0.03
mobile terminal	0.07	0.01	0.01	0.02	0.05	0.03	0.06	0.01	0.04	0.14	0.02	0.03
scalability	0.17	0	0.01	0.05	0.03	0	0.01	0	0.06	0.02	0.02	0.03
service	0.01	0.01	0	0.05	0.02	0.02	0.02	0.03	0	0.04	0.02	0.03
propagation characteristics	0.02	0.02	0.01	0.06	0.03	0.03	0.01	0.12	0.04	0.01	0.02	0.03
DFE	0	0.01	0.03	0.02	0.01	0	0.04	0.03	0.01	0.02	0.01	0.03
computer simulations	0.01	0.01	0.01	0.08	0.14	0.03	0.01	0.05	0.01	0.05	0.01	0.03
PRMA	0.01	0.07	0.03	0.03	0.01	0.03	0.09	0.1	0.01	0.02	0.01	0.03
QoS support	0.04	0	0.02	0.04	0.01	0	0.02	0.03	0.01	0.04	0.01	0.03
overhead	0.01	0.03	0.04	0.06	0.05	0.02	0.03	0.03	0.03	0.16	0	0.03
multimedia information	0.02	0.01	0	0.02	0	0.02	0.02	0	0	0.01	0	0.03
messages	0.04	0.01	0.12	0.02	0.03	0.01	0.03	0.05	0.02	0.02	0.11	0.02
pilot symbols	0.03	0.02	0	0.01	0.02	0.02	0.02	0.03	0.03	0.06	0.03	0.02
convolutional coding	0	0.01	0	0.02	0	0.02	0.01	0.02	0.03	0	0.02	0.02
transmission range	0.05	0	0.01	0.04	0.03	0.03	0.01	0	0.09	0.11	0.02	0.02
support	0.18	0	0.01	0	0.03	0	0.01	0.03	0.04	0.06	0.02	0.02
frequency selective fading	0	0.02	0.01	0.01	0.04	0.03	0.02	0.05	0.03	0.06	0.01	0.02
high-speed data services	0.04	0.01	0.02	0.05	0.02	0	0.01	0.01	0.01	0.08	0.01	0.02
wireless	0.03	0.01	0.02	0.01	0.02	0.02	0.03	0.01	0	0.03	0.01	0.02
wireless communications	0.11	0.01	0.01	0.03	0.02	0	0.01	0.03	0.02	0.02	0	0.02
receivers	0.06	0	0.01	0.19	0.14	0.04	0.01	0.04	0.05	0.14	0	0.02
wireless communication	0.02	0.01	0.06	0.01	0.01	0.01	0.01	0.03	0	0.02	0.05	0.02
power amplifier	0.09	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.03	0.03	0.02
intersymbol interference	0.1	0	0.01	0.02	0.03	0.01	0.02	0.01	0.03	0.03	0.02	0.02
data	0.03	0.01	0	0.01	0.02	0.01	0.02	0.03	0.03	0	0.02	0.02
indoor wireless communications	0.11	0	0.02	0.02	0.03	0.01	0.02	0.03	0.03	0.02	0.01	0.02
theoretical analysis	0.09	0	0	0.07	0.04	0.01	0.02	0.04	0.01	0.03	0.01	0.02
amplifier	0.08	0	0.03	0.04	0.01	0.02	0.02	0.05	0.02	0.01	0.01	0.02
medium access control MAC protocols	0.01	0.01	0.04	0.02	0.01	0.03	0.07	0.13	0.06	0.01	0.01	0.02
retransmission	0.14	0.03	0.09	0.02	0	0.03	0.02	0.02	0.04	0.03	0.17	0.02
mobile systems	0.07	0.01	0.05	0.04	0.05	0.01	0.04	0.01	0.02	0.02	0.04	0.02
mobile radio	0.07	0.01	0.02	0.01	0.03	0.01	0.03	0.03	0	0.05	0.04	0.02
Bluetooth	0.02	0.01	0	0.02	0.01	0.01	0.03	0.02	0.03	0.06	0.03	0.02
proposed system	0	0.01	0	0.11	0.08	0.01	0.04	0.01	0.03	0.03	0.03	0.02
maximum throughput	0.03	0.01	0.01	0.04	0.06	0.03	0.03	0.02	0.01	0.13	0.03	0.02
fast	0.05	0	0.01	0	0.01	0.02	0.02	0.03	0.04	0.2	0.02	0.02
indoor radio environment	0.04	0.02	0.01	0.02	0.02	0.08	0.12	0.01	0.04	0	0.02	0.02
mobile phones	0.02	0	0.02	0.07	0.05	0.01	0.04	0.01	0.03	0.06	0.01	0.02
telecommunications	0.03	0.01	0	0.01	0.02	0.02	0.02	0.02	0	0.02	0.01	0.02
maximal-ratio combining	0.18	0.02	0.03	0.01	0.02	0.01	0.02	0.01	0.03	0.01	0.01	0.02
maximum Doppler frequency	0.02	0.01	0.02	0.04	0.03	0.01	0.02	0.02	0.02	0.01	0.01	0.02
routers	0.03	0.07	0.05	0.02	0.01	0	0.03	0.02	0.08	0.02	0	0.02
systems	0.02	0.01	0.01	0.05	0.02	0.02	0.03	0.04	0.1	0.13	0.03	0.02
collision detection CSMA/CD	0.04	0.02	0.01	0	0.02	0.03	0.03	0.05	0.16	0.07	0.02	0.02
software architecture	0.04	0.01	0.01	0.02	0	0.02	0.02	0.09	0.04	0.04	0.02	0.02
MAC	0.04	0	0.01	0.03	0	0.02	0.12	0.06	0.01	0.07	0.02	0.02
protocol parameters	0.02	0.01	0	0	0.05	0	0.05	0.16	0.06	0.04	0.02	0.02
RF	0.01	0.02	0	0.01	0	0.04	0.01	0.1	0.02	0	0.02	0.02
carriers	0.04	0.01	0.01	0.02	0.01	0	0.03	0.05	0.11	0.04	0.02	0.02
fading channel	0.04	0.01	0.04	0.06	0.02	0.01	0.02	0	0.02	0.14	0.02	0.02
architectures	0.02	0.02	0.03	0.04	0.01	0	0.01	0	0.06	0.05	0	0.02
scheme	0.09	0.01	0.14	0.01	0	0.01	0	0	0.03	0.04	0.13	0.02
wireless LAN systems	0.03	0.03	0.04	0.04	0.08	0.02	0	0.02	0	0.02	0.04	0.02
research	0	0	0.02	0.03	0.01	0.01	0.03	0.02	0.14	0.02	0.04	0.02

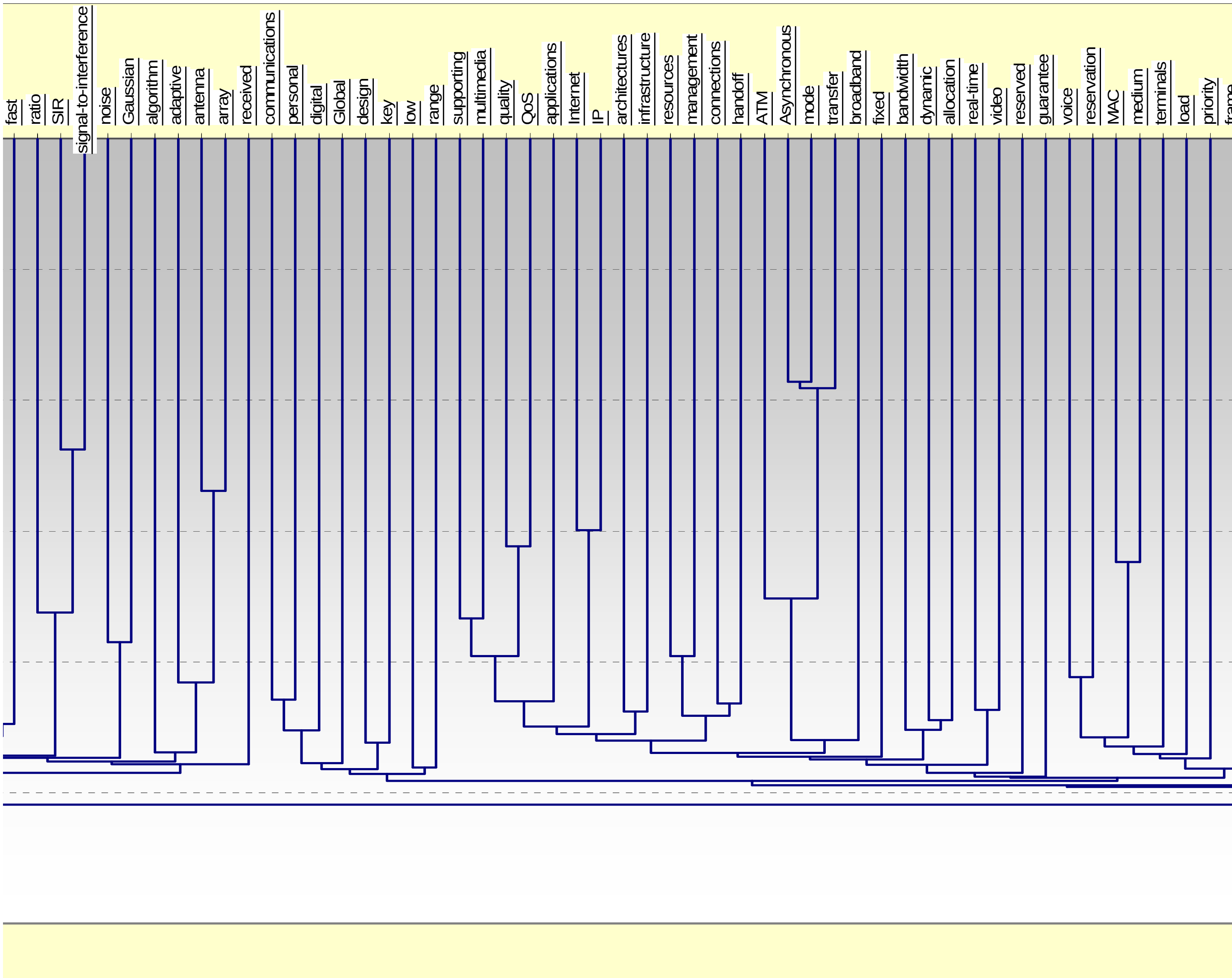
received signal	0.18	0	0.01	0.02	0.08	0.01	0.02	0.06	0	0.01	0.04	0.02
protocols	0.02	0.01	0	0.02	0.02	0.02	0.02	0.01	0.01	0.06	0.02	0.02
signal processing	0.02	0.02	0.01	0.02	0	0.05	0.02	0.19	0.03	0.02	0.02	0.02
DECT	0.04	0	0	0.04	0.05	0.01	0.01	0.02	0.02	0.1	0.02	0.02
measurements	0.05	0.01	0.01	0.02	0.02	0.02	0.01	0.04	0	0.06	0.01	0.02
operation	0.02	0.02	0.03	0.06	0.03	0.03	0.13	0.05	0.08	0.01	0.01	0.02
network congestion	0.05	0.05	0.05	0.02	0.03	0.03	0.04	0	0.01	0.05	0.05	0.02
BER	0.01	0.01	0	0.03	0.01	0.01	0.02	0.03	0.01	0.05	0.03	0.02
output power	0.02	0.01	0	0.04	0.03	0.01	0.04	0.04	0.04	0.1	0.03	0.02
ad hoc networks	0	0	0	0.01	0.02	0.02	0.01	0.04	0.03	0	0.03	0.02
simulation experiments	0.02	0.01	0	0	0.01	0.02	0	0.03	0.03	0.03	0.02	0.02
wireless access	0.01	0.03	0	0.02	0.01	0.2	0.01	0.02	0.07	0.16	0.02	0.02
Global System	0.04	0.01	0	0.06	0.05	0.08	0	0.07	0.03	0.14	0.01	0.02
simulation model	0.04	0.01	0.02	0.02	0.03	0	0.13	0.01	0.14	0.05	0.01	0.02
BER performance	0.04	0.02	0.03	0.05	0.03	0.02	0.02	0.03	0.02	0	0.01	0.02
spread spectrum techniques	0.02	0	0.01	0	0.02	0.07	0.04	0.02	0.06	0.12	0.01	0.02
transport	0.05	0.02	0.02	0.02	0.01	0.03	0.01	0.04	0	0.04	0	0.02
flexibility	0.07	0.01	0.07	0.05	0.03	0.06	0.02	0.05	0.01	0.02	0.07	0.02
dispersed voice	0.04	0.02	0.1	0	0.01	0.04	0.02	0.14	0.04	0.05	0.06	0.02
stability	0.09	0	0.03	0	0.1	0.01	0.01	0.06	0.02	0.04	0.05	0.02
convolutional codes	0.05	0.01	0	0.03	0.01	0.03	0.02	0.03	0.03	0.05	0.03	0.02
circuits	0.03	0.01	0.01	0.02	0	0.03	0.02	0.04	0.01	0.05	0.03	0.02
backoff algorithm	0.05	0	0.01	0	0	0.01	0.01	0.01	0.02	0.04	0.01	0.02
nodes	0.08	0.02	0.01	0.01	0.02	0	0.01	0.02	0.03	0.05	0.01	0.02
algorithms	0.02	0.03	0	0.05	0.05	0.02	0	0.14	0.08	0.04	0.01	0.02
multicasting	0.19	0.01	0.01	0.03	0.08	0	0	0.04	0	0	0.01	0.02
protocol performance	0.12	0.02	0.12	0.01	0.01	0.01	0.01	0.03	0.02	0.05	0.11	0.02
IEEE 802.11 protocol	0.01	0.02	0.01	0	0.03	0.05	0.01	0	0.01	0.04	0.03	0.02
channel utilization	0.05	0.02	0	0.03	0.02	0.02	0.01	0.16	0.04	0.02	0.02	0.02
transmission rate	0.08	0	0.01	0.05	0.02	0.02	0.01	0.05	0.03	0.02	0.02	0.02
mobility management	0.01	0.02	0.01	0.02	0.02	0.04	0.07	0.08	0.04	0.01	0.01	0.02
ISDN	0.02	0.03	0.02	0.01	0.02	0	0.07	0.06	0.03	0.01	0.01	0.02
QoS requirements	0.01	0.01	0.01	0	0	0	0.01	0	0	0.04	0.01	0.02
waiting time	0.05	0.02	0.03	0.04	0.04	0.04	0.03	0.03	0.2	0.01	0.01	0.02
PC	0	0.01	0.01	0.01	0.02	0.02	0.04	0.02	0.05	0.03	0.04	0.02
TCP	0.02	0.01	0	0.03	0.01	0.03	0.02	0.07	0.01	0.03	0.03	0.02
transmitted power	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.14	0.02	0.01	0.02	0.02
additive white Gaussian noise AWGN	0.09	0.01	0.01	0	0	0.01	0.01	0.01	0.02	0.05	0.02	0.02
network	0.03	0.01	0.02	0	0.02	0	0.03	0	0.01	0.08	0.02	0.02
prototype implementation	0.04	0	0.01	0.04	0.02	0.07	0	0.01	0.03	0.15	0.02	0.02
channel access	0.15	0	0.02	0.01	0	0.01	0.01	0.01	0.02	0.01	0.01	0.02
air interface	0.02	0.01	0	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0	0.02
speech	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0	0.02	0.02	0	0.02
multipath propagation	0.05	0	0.05	0.03	0	0.01	0.02	0.02	0	0.02	0.05	0.02
antenna	0.05	0.01	0.01	0.01	0.02	0.03	0.08	0.04	0.03	0.04	0.03	0.02
mobile environment	0.04	0	0	0.01	0.02	0	0.03	0.02	0.01	0.04	0.03	0.02
voice packet	0.01	0	0.03	0.01	0.01	0.03	0.04	0	0.09	0.06	0.02	0.02
receiver	0.1	0	0.03	0.01	0.02	0.03	0	0.04	0.02	0.01	0.02	0.02
TDMA scheme	0.16	0	0.01	0.02	0.05	0	0	0.05	0	0.02	0	0.02
wireless data	0.16	0	0.01	0.03	0.04	0.04	0.01	0.06	0.01	0.05	0.03	0.01
packet length	0.03	0.01	0	0	0.01	0.02	0.02	0.04	0.01	0.06	0.02	0.01
Rayleigh fading channels	0.01	0	0.01	0.01	0.01	0.01	0	0.01	0	0.16	0.02	0.01
uplink performance	0.03	0.02	0	0	0.03	0.01	0.05	0.19	0.04	0.03	0.01	0.01
B-ISDN	0.05	0	0	0.01	0.01	0	0.01	0.01	0	0	0.01	0.01
low power consumption	0.03	0	0.02	0	0.04	0.01	0.04	0.1	0.1	0.03	0.01	0.01
wireless channel	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.07	0.02	0.02	0.01	0.01
integrated services	0.02	0.03	0	0	0.05	0.01	0.02	0.02	0.06	0.01	0.01	0.01
ad-hoc networks	0.06	0.04	0.02	0.03	0.01	0	0.04	0.04	0.02	0.02	0	0.01
error control	0.07	0.02	0.02	0.06	0.04	0.17	0.02	0.1	0.05	0.05	0.03	0.01
code rate	0.1	0.01	0	0.05	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01
response time	0	0.01	0	0.02	0.01	0.04	0.1	0.01	0.04	0.06	0.01	0.01
transmitter	0.04	0.02	0.04	0.01	0.01	0.06	0.04	0.14	0.04	0.02	0.03	0.01
network topology	0.01	0	0.01	0.02	0.01	0.01	0.04	0.06	0	0.03	0.02	0.01
broadband wireless systems	0.02	0.01	0.01	0	0.01	0.02	0.02	0.03	0.01	0.02	0.02	0.01
bit error rate BER performance	0.08	0.02	0.03	0.03	0.01	0.01	0.03	0.03	0.04	0.04	0.02	0.01
ATM switches	0.03	0.01	0.01	0.01	0.02	0.04	0.01	0.01	0.02	0.02	0.01	0.01
turbo coding	0.01	0.01	0.02	0	0	0.02	0.04	0.01	0.02	0.03	0.01	0.01
wireless environments	0.07	0	0.02	0.04	0.01	0	0.03	0	0	0.02	0	0.01
frame	0.01	0	0.01	0.02	0.04	0.01	0.02	0.04	0.02	0.06	0	0.01
mobile networks	0.05	0	0	0.01	0.01	0.03	0.06	0.07	0.02	0.06	0	0.01
mobile phase	0.11	0.01	0.1	0.02	0.04	0	0.02	0.06	0.01	0.02	0.11	0.01
components	0.06	0.03	0.12	0.01	0	0.04	0.01	0.02	0.02	0.02	0.09	0.01
ATM	0.04	0	0.01	0.02	0	0.02	0.01	0.01	0.02	0.02	0.03	0.01
QoS guarantees	0.15	0.01	0.05	0.03	0	0.03	0.01	0.03	0.03	0.07	0.02	0.01

real-time applications	0	0.01	0.01	0.02	0.03	0.01	0.02	0.01	0.03	0.03	0.02	0.01
core network	0.02	0.01	0.04	0.02	0.04	0.01	0.01	0.06	0.06	0.05	0.01	0.01
AAL2	0	0.01	0.02	0.02	0	0.03	0.08	0.02	0.01	0.03	0	0.01
Rake combining	0.02	0	0.01	0.05	0.02	0.02	0.03	0.02	0	0.16	0	0.01
wireless channels	0.11	0.01	0.01	0.02	0	0.02	0	0.01	0.02	0	0	0.01
throughput performance	0.02	0.02	0.09	0.02	0.02	0.03	0.01	0.04	0.05	0.01	0.2	0.01
center frequency	0.08	0	0.03	0.02	0.01	0.01	0.03	0.02	0.04	0.01	0.03	0.01
phase noise	0.05	0.01	0.01	0.09	0.04	0.01	0.04	0.01	0.06	0.07	0.03	0.01
images	0.05	0.01	0	0.04	0	0	0.03	0.02	0	0.04	0.03	0.01
wide bandwidth	0.01	0.01	0	0.1	0.07	0.03	0.02	0.04	0.02	0.03	0.02	0.01
wireless link	0.01	0.01	0	0.02	0.02	0.03	0.01	0.13	0.01	0.01	0.02	0.01
combination	0.04	0.01	0.03	0.01	0.03	0.05	0.05	0.16	0	0.04	0.01	0.01
Doppler spread	0.03	0.01	0.01	0.01	0.04	0.13	0.05	0	0.03	0	0.01	0.01
interfering users	0.01	0.02	0.02	0.04	0.03	0.03	0.02	0.01	0.03	0.17	0.01	0.01
mobile environments	0.03	0	0.01	0.03	0.04	0.01	0.03	0.05	0.01	0.03	0	0.01
link	0.05	0.1	0.07	0.06	0.05	0.06	0.16	0.12	0.16	0.03	0.06	0.01
antenna diversity reception	0.01	0.01	0.04	0.03	0.03	0.01	0.01	0.04	0.02	0.06	0.04	0.01
carrier	0.06	0.02	0.01	0.04	0.05	0.04	0.01	0.01	0.01	0	0.04	0.01
data throughput	0.02	0	0.02	0.01	0.01	0.08	0.02	0.03	0.01	0.13	0.03	0.01
wireless LAN	0.03	0.01	0.01	0.05	0.06	0.03	0.02	0.03	0.01	0.06	0.03	0.01
switching	0.05	0	0.04	0.02	0.01	0.02	0.06	0.01	0.03	0.01	0.03	0.01
spectrum efficiency	0.06	0.04	0.01	0.04	0.02	0.04	0.04	0.03	0	0.01	0.03	0.01
real-time traffic	0.05	0	0	0.06	0.06	0.02	0.02	0.06	0.01	0	0.03	0.01
response	0.01	0.01	0.01	0.01	0.01	0.01	0	0.1	0.01	0.03	0.02	0.01
proliferation	0.04	0	0.01	0.04	0.01	0	0.03	0.02	0.01	0.04	0.02	0.01
demodulation	0.1	0.01	0.02	0.04	0.04	0	0.01	0.05	0	0	0.02	0.01
propagation environment	0.04	0.03	0	0.02	0.03	0.04	0.15	0.02	0.01	0.02	0.01	0.01
data packets	0.02	0.01	0	0.02	0.01	0	0.02	0.03	0.02	0.05	0.01	0.01
connectivity	0.03	0.01	0.01	0	0.02	0.02	0.01	0.01	0.03	0.03	0.01	0.01
fixed ATM networks	0.07	0.02	0.01	0.01	0.04	0.14	0.12	0.01	0.06	0.07	0	0.01
terminal mobility	0.03	0.01	0	0	0.02	0.01	0.02	0.01	0.03	0.01	0	0.01
indoor environments	0.05	0.02	0.02	0.01	0.02	0.03	0.03	0.1	0.01	0.07	0	0.01
collision	0.07	0.03	0.05	0.03	0.1	0.02	0.03	0.07	0.01	0.05	0.07	0.01
modulation	0	0.02	0	0.01	0.03	0.02	0.04	0	0.05	0.02	0.03	0.01
lead	0.03	0	0.04	0.01	0.02	0.02	0.01	0.01	0.05	0.06	0.03	0.01
Gaussian approximation	0.08	0.01	0	0.01	0.04	0.04	0.01	0.02	0.04	0.04	0.02	0.01
wireless communication system	0	0	0	0.01	0.02	0.05	0.16	0.03	0.01	0.01	0.02	0.01
voice services	0.03	0.01	0.01	0.01	0.02	0.03	0.01	0.03	0.02	0.02	0.01	0.01
host mobility	0.01	0.01	0.02	0.06	0.08	0.02	0.02	0.05	0.06	0	0.01	0.01
cell capacity	0.01	0.01	0.01	0.03	0.01	0	0.04	0.01	0.18	0.02	0.01	0.01
mobility support	0.02	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0	0.01	0.01
spreading code	0.03	0.01	0	0.08	0.12	0.02	0.02	0	0	0.03	0.01	0.01
mobile radio channel	0.14	0.01	0.01	0.02	0.02	0	0.02	0	0.01	0.03	0	0.01
frequency	0.05	0	0.01	0	0.01	0.01	0.16	0.18	0.03	0.01	0	0.01
bit error rate	0.03	0	0.17	0	0.03	0.01	0.04	0.02	0.01	0.05	0.12	0.01
multimedia applications	0	0.02	0.08	0.01	0.02	0.01	0.01	0.08	0.06	0.02	0.07	0.01
local area network	0.02	0	0.01	0.04	0.01	0.01	0	0.02	0.05	0.1	0.02	0.01
scenario	0.04	0.01	0	0.01	0	0.03	0	0.04	0.02	0.04	0.02	0.01
mobile host	0.04	0.06	0.04	0.01	0.03	0.01	0.02	0.01	0.09	0.02	0.02	0.01
turbo codes	0.04	0	0	0.04	0.02	0	0.03	0.01	0.02	0.03	0.01	0.01
wireless access systems	0.03	0.01	0.02	0.04	0.01	0.03	0.02	0.02	0.02	0.03	0.01	0.01
devices	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.01	0.03	0	0.01
Collision Detection	0.09	0.01	0.02	0.05	0.01	0.01	0.04	0.1	0.06	0	0	0.01
application	0.05	0.01	0.05	0.07	0.04	0.14	0.06	0.02	0.14	0.02	0.04	0.01
radio link	0.04	0.01	0	0.04	0.01	0.03	0.02	0.02	0.04	0.04	0.03	0.01
received signals	0.08	0.07	0.03	0.01	0.01	0.01	0.02	0.03	0.18	0	0.02	0.01
image	0	0.01	0	0	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.01
performance evaluation	0.02	0.02	0.01	0.03	0.03	0	0.04	0.03	0	0.19	0.02	0.01
higher throughput	0.11	0.02	0.02	0.01	0.04	0.01	0.02	0.03	0.01	0.01	0.01	0.01
CSMA/CD	0.06	0.01	0	0.01	0.02	0	0.01	0.01	0.02	0.01	0.01	0.01
mobility	0.04	0	0.02	0.04	0.02	0	0	0.01	0	0.01	0	0.01
Dynamic Source	0.03	0.01	0.07	0	0.01	0.07	0.04	0.01	0.03	0.01	0.05	0.01
packets	0.04	0.02	0	0	0.02	0.02	0.02	0.11	0.01	0.01	0.02	0.01
signaling	0.03	0.01	0	0.01	0.03	0.03	0.04	0.02	0	0.13	0.02	0.01
ISI	0.02	0.01	0.01	0.03	0.02	0.03	0.01	0	0.01	0.02	0.01	0.01
interoperability	0.07	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0	0.01
interconnection	0.02	0	0.01	0.01	0	0.01	0.02	0.01	0.02	0	0	0.01
wired networks	0.04	0.01	0.04	0.02	0.01	0.03	0	0.01	0	0	0	0.01
token ring	0.04	0.02	0.06	0	0	0.07	0.06	0.03	0.02	0.04	0.04	0
QoS	0.01	0	0.01	0.04	0.07	0.03	0.01	0.01	0.03	0.02	0.04	0
constant bit rate CBR	0.04	0	0.01	0	0.05	0.02	0.05	0.02	0.01	0.11	0.02	0
terminals	0.05	0.01	0	0.03	0.04	0.01	0.01	0.01	0	0.03	0.02	0

Internet	0.02	0.01	0	0.01	0.03	0.01	0.02	0.01	0.02	0.01	0.02	0
average delay	0.03	0	0.05	0.01	0.01	0.01	0.09	0.19	0.1	0.01	0.01	0
area	0.03	0	0.01	0.01	0.02	0.04	0.04	0.01	0.05	0.13	0.01	0
mobile ATM	0.02	0.01	0	0.02	0	0.01	0.06	0.02	0.04	0	0.01	0
SNR	0.08	0	0	0.02	0.02	0.02	0	0.02	0	0.01	0.01	0
portable	0	0.01	0	0.03	0.02	0.04	0.03	0.06	0.04	0.04	0.05	0
high data rates	0.08	0.02	0.03	0.13	0.15	0.01	0.05	0.02	0	0.01	0.03	0
WLANs	0.05	0.01	0	0.02	0	0.02	0	0.02	0.02	0.02	0.03	0
direct sequence code division multiple ac	0.06	0.01	0	0.05	0.02	0.05	0.12	0.08	0.03	0	0.03	0
communication systems	0.19	0.02	0.02	0.07	0.04	0.01	0.01	0.01	0	0.03	0.02	0
theoretical results	0.01	0.01	0.01	0.01	0	0.02	0.04	0.01	0.05	0.03	0.02	0
coding	0.03	0.01	0.02	0.04	0.03	0	0.03	0.02	0.01	0.02	0.02	0
retransmissions	0.04	0.01	0	0	0.02	0.01	0.01	0.06	0.01	0.02	0.01	0
demodulator	0.06	0.01	0	0.05	0.02	0.01	0.01	0.06	0.03	0.01	0.01	0
antennas	0.03	0.03	0.01	0.05	0.05	0.15	0.05	0.07	0.02	0.02	0.01	0
power distribution	0.04	0.01	0.01	0.01	0.02	0.02	0.19	0.03	0.02	0.03	0	0
OFDM system	0.05	0.02	0	0.03	0.04	0.01	0.03	0.03	0.02	0.01	0	0
channel coding	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.07	0	0
experimental results	0.05	0.01	0.02	0.14	0.12	0	0.03	0.08	0.05	0.04	0	0
environment	0.05	0	0	0.02	0.02	0	0.02	0.01	0.04	0.17	0	0
analytical model	0.19	0.01	0.03	0.06	0.03	0.01	0.04	0.06	0.01	0.03	0.07	0
finite number	0.04	0.01	0.05	0.17	0.1	0	0.1	0.06	0.04	0.01	0.05	0
modulation scheme	0.08	0.01	0	0.02	0.02	0.01	0.03	0	0.03	0.01	0.02	0
novel algorithm	0.02	0.01	0.03	0	0.02	0	0.01	0.09	0.1	0.02	0.02	0
equalization	0.02	0.01	0	0.02	0.03	0.02	0.03	0.02	0.03	0.05	0.02	0
bit error rates	0.04	0.03	0.01	0.05	0.02	0.01	0.03	0.03	0.14	0.01	0.01	0
wireless ad hoc networks	0.01	0.01	0	0.03	0.03	0	0.03	0.01	0.04	0.03	0.01	0
Internet Protocol	0.03	0.01	0.01	0.01	0.03	0.03	0.02	0.01	0.02	0.01	0.01	0
protocol stack	0.05	0.01	0.02	0.05	0.03	0	0.02	0.03	0.02	0.02	0	0
traffic	0.03	0.01	0.01	0.02	0	0.03	0.06	0.02	0.05	0.01	0	0
multipath channels	0.01	0	0.01	0.04	0.02	0.01	0	0	0.05	0.06	0.03	0
LAN	0.02	0.04	0.02	0.07	0	0.06	0.1	0.04	0.13	0.06	0.03	0
same frequency band	0.08	0.02	0.01	0.08	0.1	0.01	0.03	0.17	0.01	0	0.01	0
packet	0.01	0.01	0	0.04	0	0.01	0.04	0.05	0.09	0.08	0.01	0
frequency diversity	0.07	0.02	0	0.01	0.04	0.13	0.1	0.01	0.05	0.07	0.01	0
severe multiple access interference MAI	0	0.01	0.01	0.08	0.05	0.01	0.04	0	0.02	0.01	0	0
efficient algorithm	0.03	0.02	0.05	0.03	0.02	0.01	0.01	0.03	0.06	0.1	0.03	0
training	0.04	0.02	0.01	0.04	0.07	0.04	0.03	0.05	0.02	0.02	0.03	0
features	0.09	0	0	0.02	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0
services	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0	0.02	0
congestion	0.04	0.02	0.01	0.12	0.07	0	0.03	0.01	0	0.07	0.02	0
processing gain	0.03	0.04	0.05	0.01	0	0.03	0.02	0.16	0.03	0.02	0.01	0

Appendix 9 – Word Dendrogram




fast
ratio
SIR
signal-to-interference
noise
Gaussian
algorithm
adaptive
antenna
array
received
communications
personal
digital
Global
design
key
low
range
supporting
multimedia
quality
QoS
applications
Internet
IP
architectures
infrastructure
resources
management
connections
handoff
ATM
Asynchronous
mode
transfer
broadband
fixed
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voice
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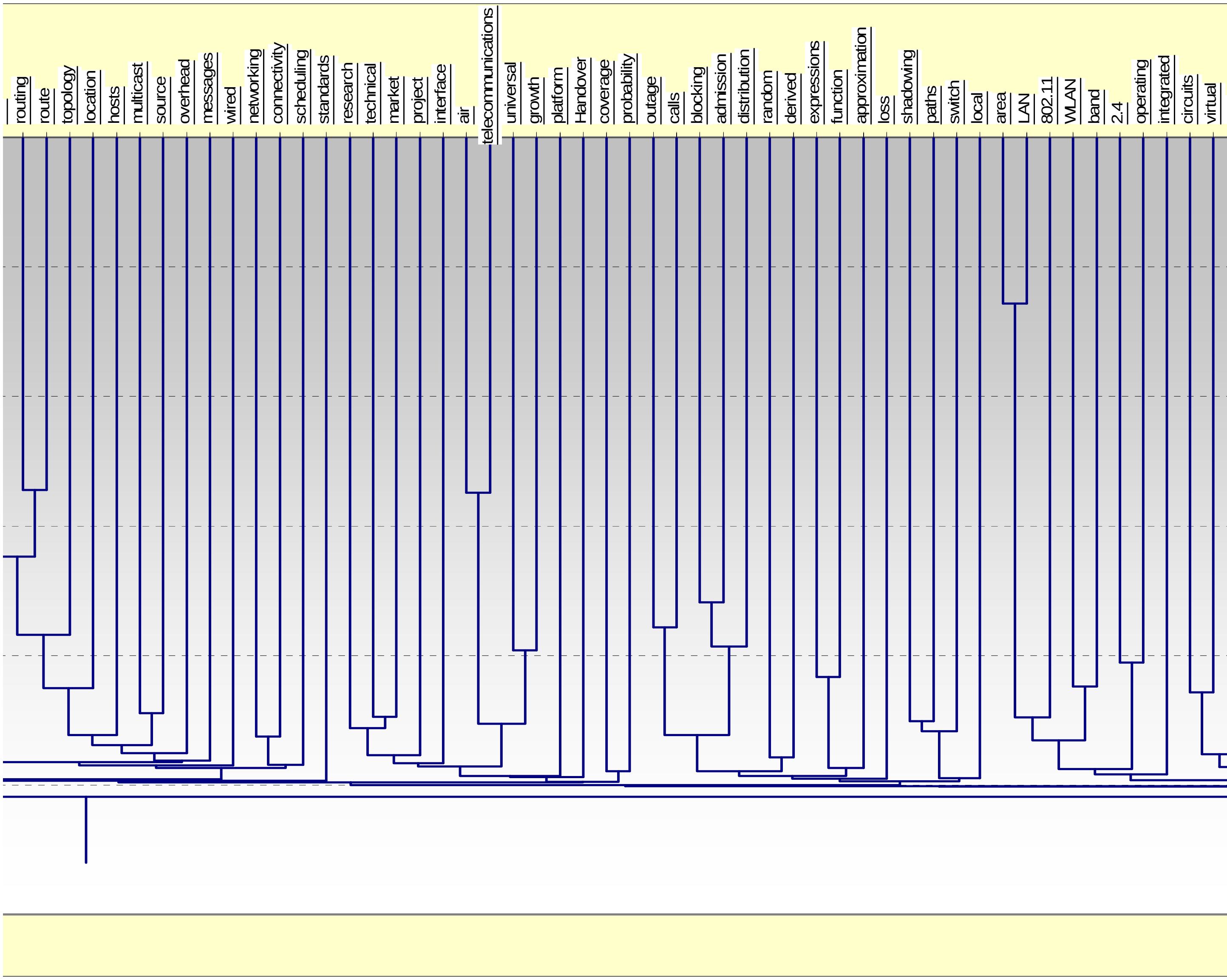
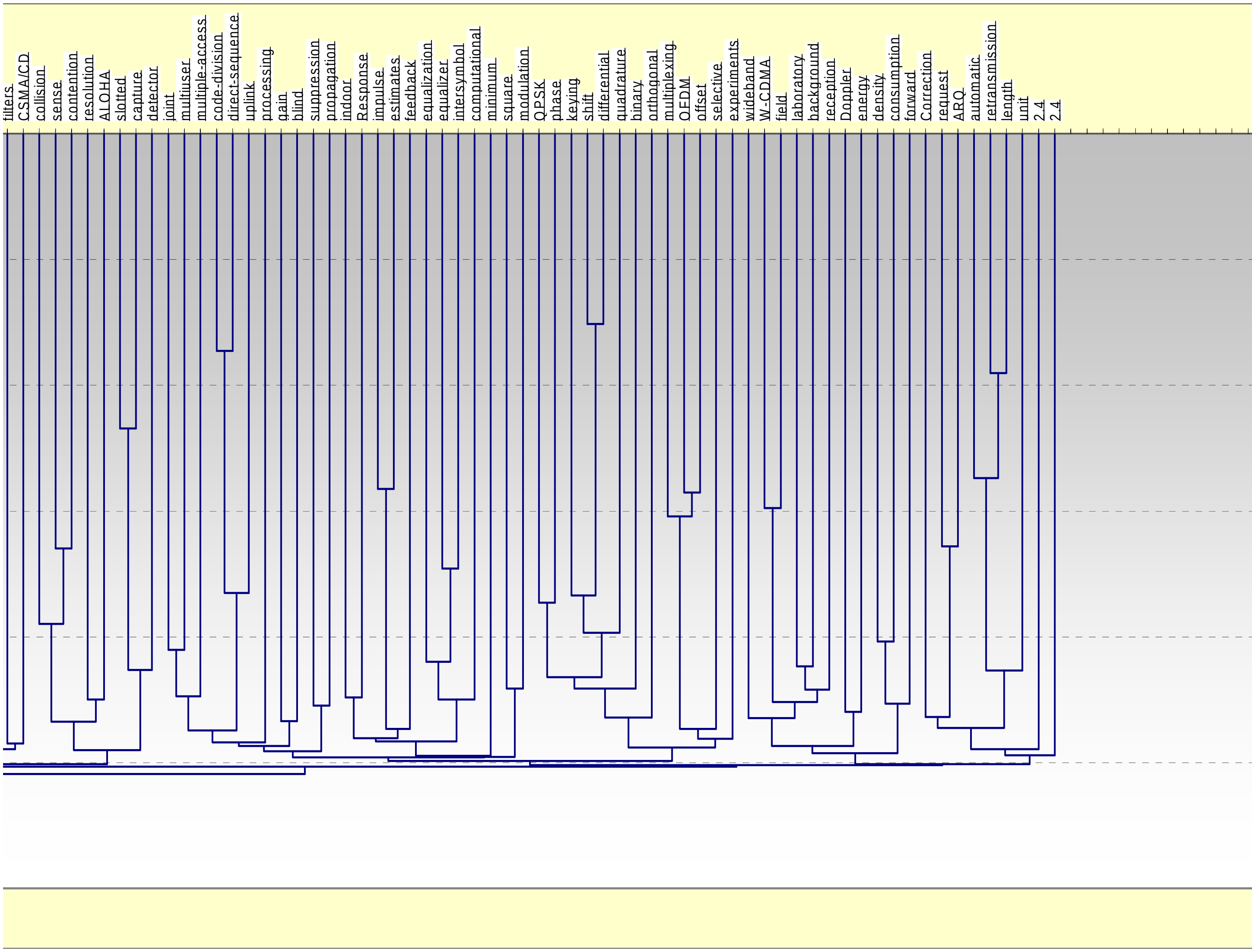
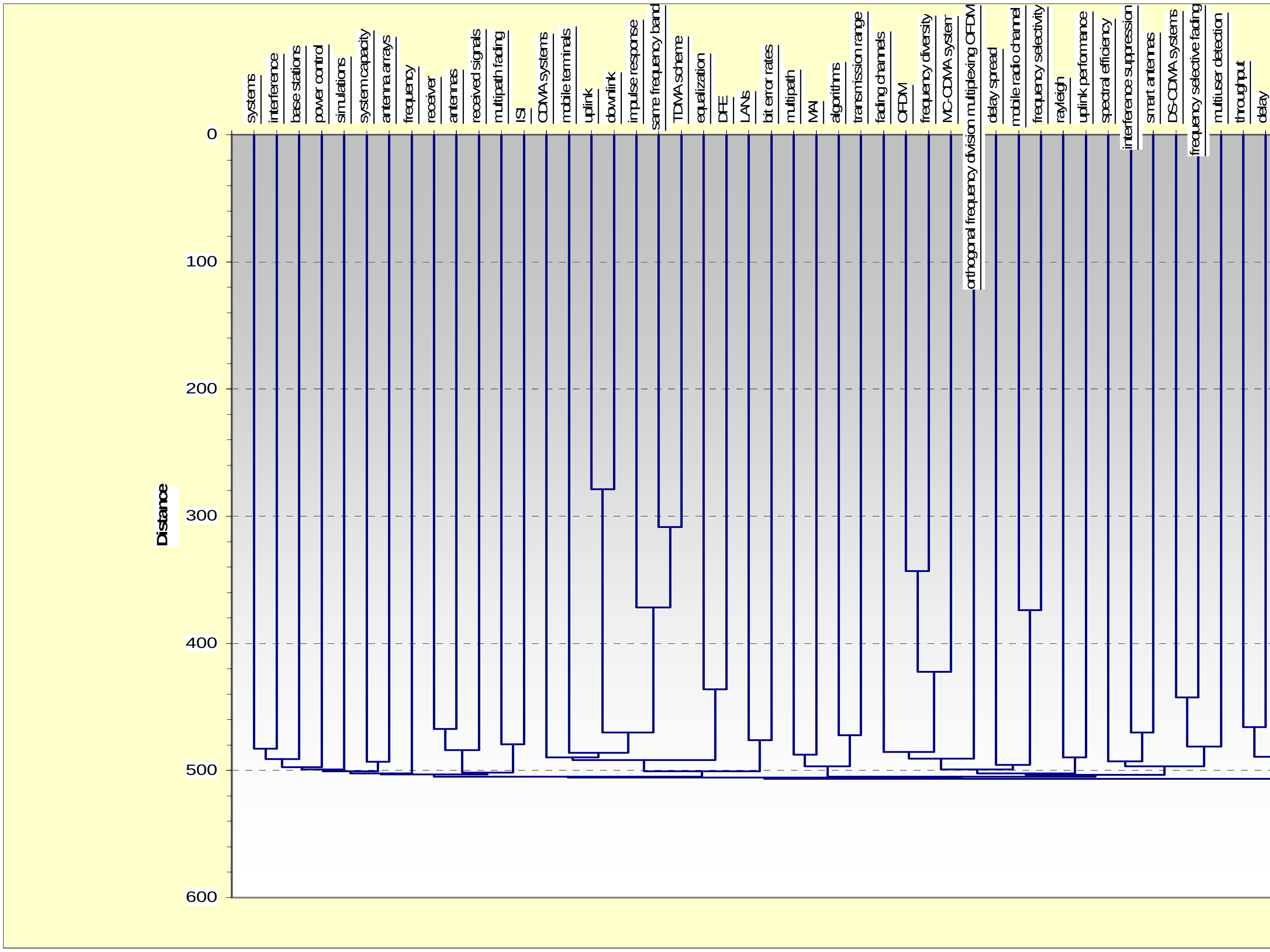
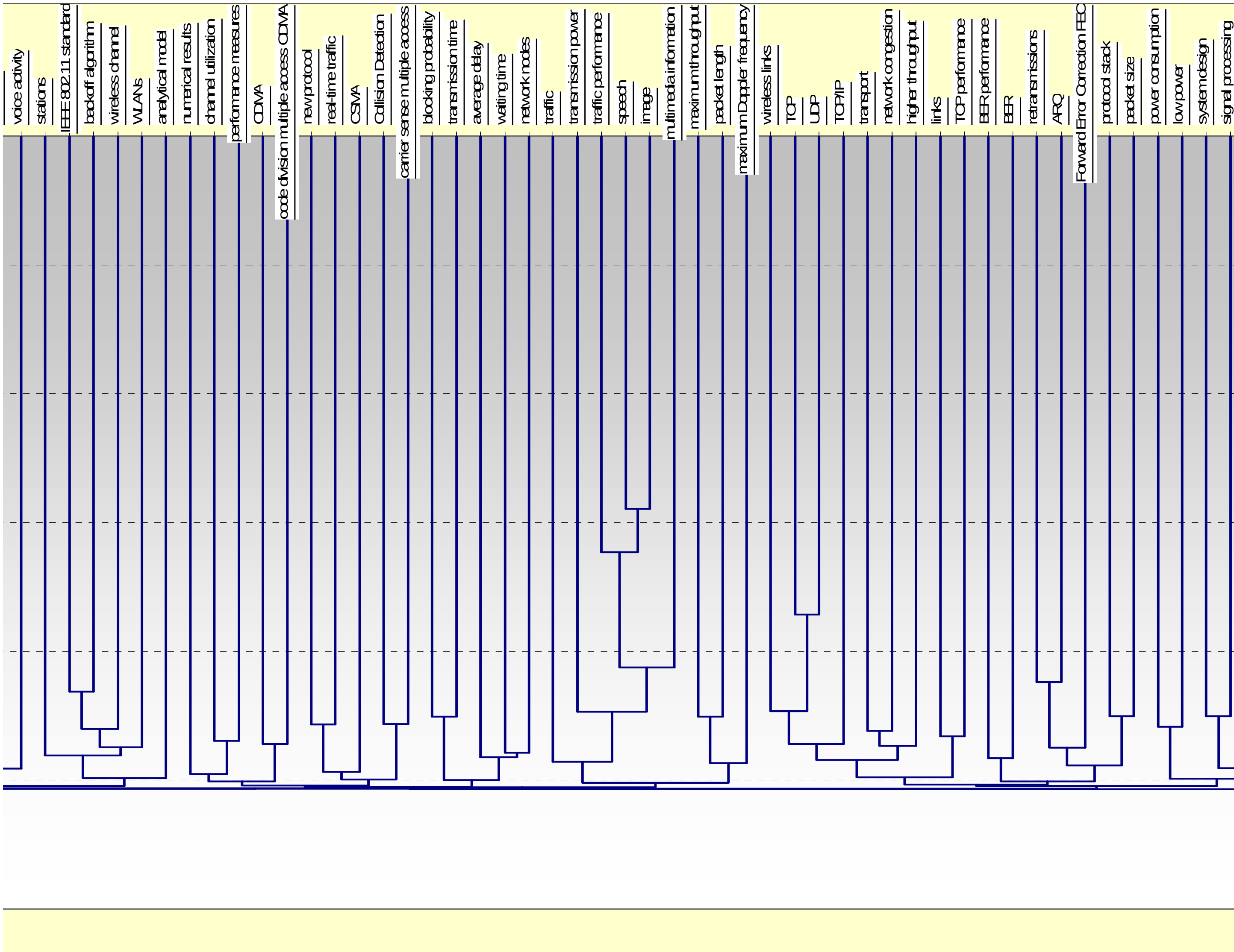
MAC
medium
terminals
load
priority

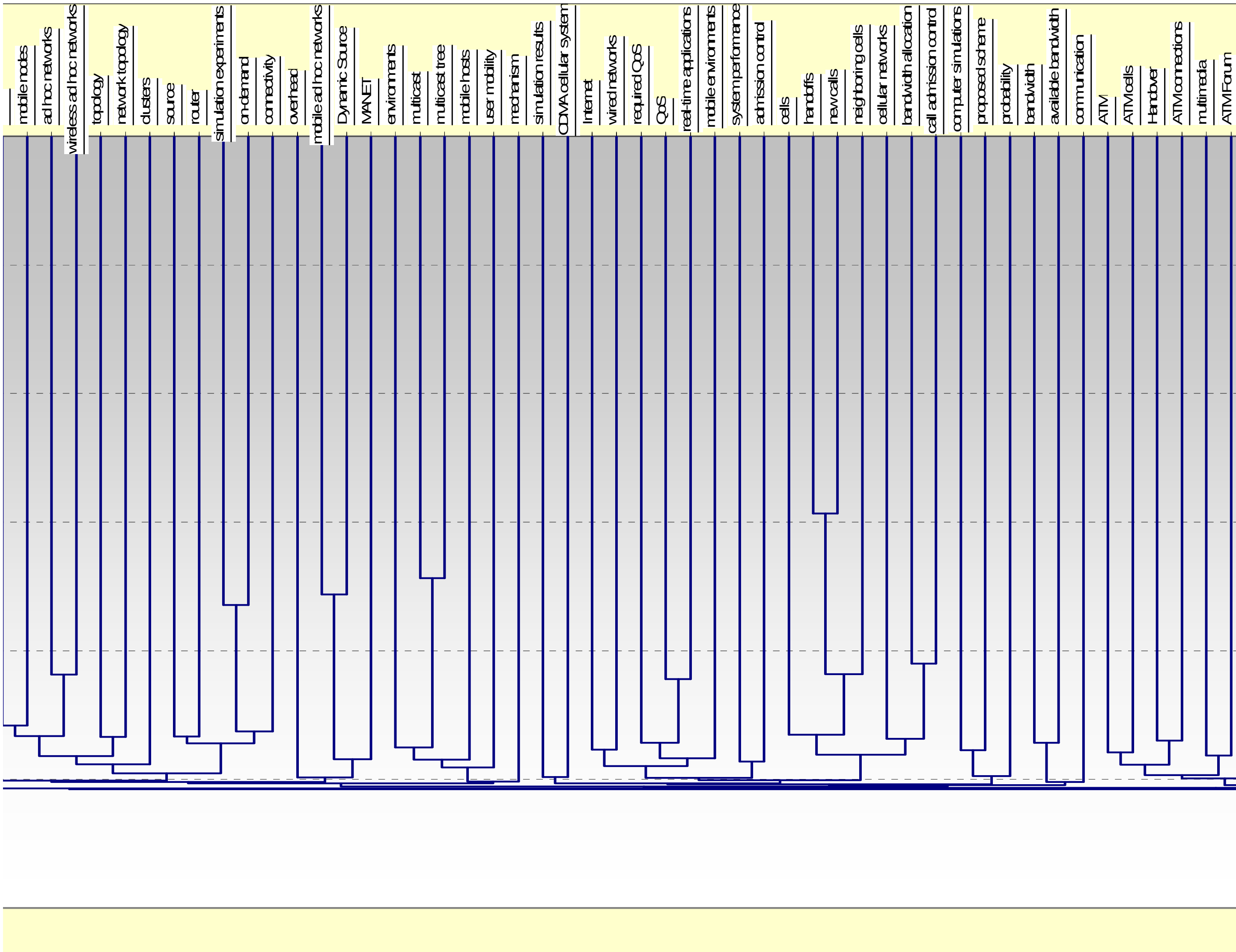

routing
route
topology
location
hosts
multicast
source
overhead
messages
wired
networking
connectivity
scheduling
standards
research
technical
market
project
interface
air
telecommunications
universal
growth
platform
Handover
coverage
probability
outage
calls
blocking
admission
distribution
random
derived
expressions
function
approximation
loss
shadowing
paths
switch
local
area
LAN
802.11
WLAN
band
2.4
operating
integrated
circuits
virtual

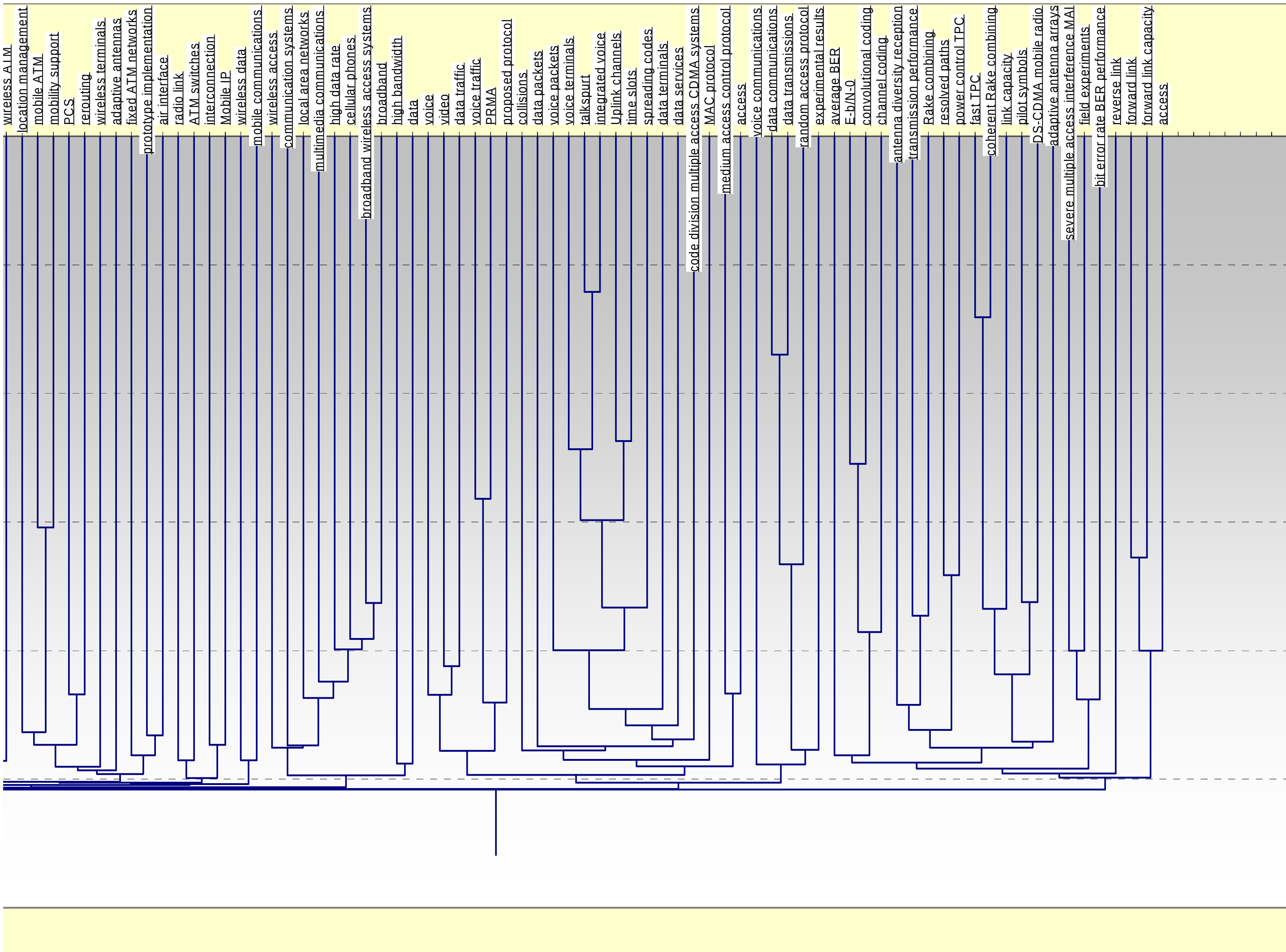

filters
CSMA/CD
collision
sense
contention
resolution
ALOHA
slotted
capture
detector
joint
multiuser
multiple-access
code-division
direct-sequence
uplink
processing
gain
blind
suppression
propagation
indoor
Response
impulse
estimates
feedback
equalization
equalizer
intersymbol
computational
minimum
square
modulation
QPSK
phase
keying
shift
differential
quadrature
binary
orthogonal
multiplexing
OFDM
offset
selective
experiments
wideband
W-CDMA
field
laboratory
background
reception
Doppler
energy
density
consumption
forward
Correction
request
ARQ
automatic
retransmission
length
unit
2.4
2.4

Appendix 10 – Phrase Dendrogram




voice activity
stations
IEEE 802.11 standard
backoff algorithm
wireless channel
WLANs
analytical model
numerical results
channel utilization
performance measures
CDMA
code division multiple access CDMA
new protocol
real-time traffic
CSMA
Collision Detection
carrier sense multiple access
blocking probability
transmission time
average delay
waiting time
network nodes
traffic
transmission power
traffic performance
speech
image
multimedia information
maximum throughput
packet length
maximum Doppler frequency
wireless links
TCP
UDP
TCP/IP
transport
network congestion
higher throughput
links
TCP performance
BER performance
BER
retransmissions
ARQ
Forward Error Correction FEC
protocol stack
packet size
power consumption
low power
system design
signal processing


mobile nodes
ad hoc networks
wireless ad hoc networks
topology
network topology
clusters
source
router
simulation experiments
on-demand
connectivity
overhead
mobile ad hoc networks
Dynamic Source
MANET
environments
multicast
multicast tree
mobile hosts
user mobility
mechanism
simulation results
CDMA cellular system
Internet
wired networks
required QoS
QoS
real-time applications
mobile environments
system performance
admission control
cells
handoffs
new calls
neighboring cells
cellular networks
bandwidth allocation
call admission control
computer simulations
proposed scheme
probability
bandwidth
available bandwidth
communication
ATM
ATM cells
Handover
ATM connections
multimedia
ATM Forum


wireless ATM
location management
mobile ATM
mobility support
PCS
rerouting
wireless terminals
adaptive antennas
fixed ATM networks
prototype implementation
air interface
radio link
ATM switches
interconnection
Mobile IP
wireless data
mobile communications
wireless access
communication systems
local area networks
multimedia communications
high data rate
cellular phones
broadband wireless access systems
broadband
high bandwidth
data
voice
video
data traffic
voice traffic
PRMA
proposed protocol
collisions
data packets
voice packets
voice terminals
talkspurt
integrated voice
Uplink channels
time slots
spreading codes
data terminals
data services
code division multiple access CDMA systems
MAC protocol
medium access control protocol
access
voice communications
data communications
data transmissions
random access protocol
experimental results
average BER
E-b/N-0
convolutional coding
channel coding
antenna diversity reception
transmission performance
Rake combining
resolved paths
power control TPC
fast TPC
coherent Rake combining
link capacity
pilot symbols
DS-CDMA mobile radio
adaptive antenna arrays
severe multiple access interference MAI
field experiments
bit error rate BER performance
reverse link
forward link
forward link capacity
access

APPENDIX 11 – GREEDY STRING TILING ELEMENTAL CLUSTERS

(93) Cluster 1 (**cdma, access, multiple, system, code, division, mobile, systems, wireless**) – focuses on CDMA (Code-Division Multiple Access) Schemes for mobile wireless systems

(62) Cluster 2 (**atm, wireless, network, mobile, mobility, service, services, qos, protocol**) – focuses on ATM (Asynchronous Transfer Mode) within wireless networks to guarantee Qos (Quality of Service) support at all times.

(43) Cluster 3 (**cdma, code, access, multiple, system, mobile, division, sequence, error, direct, wireless, communications, multipath, fading, receiver, systems, channel, signal, bitcommunication, interference**) – focuses on an interference cancellation receiver for applications in DS/CDMA (Direct-Sequence Code-Division Multiple Access) uplink communications.

(42) Cluster 4 (**access, wireless, mac, protocol, network, atm, control, traffic, channel, based, paper, networks, scheme,**) – focuses on MAC (Medium Access Control) protocols of wireless ATM (Asynchronous Transfer Mode) networks to improve Bit rate.

(42) Cluster 5 (**cdma , system , capacity , link , interference , mobile, cell , access, multiple, cellular , systems, division, traffic , network, code, base , user , power , station**) – focuses on single and multiple-cell Code-division Multiple Access networks developed from traffic models to improve Quality of Service support.

(39) Cluster 6 (**wireless , atm , access , system , systems , services , networks, broadband , based , network , protocol , mobile, multimedia, high,**) – focuses on ATM (Asynchronous Transfer Mode)-based broadband networks to transmit data.

(38) Cluster 7 (**cdma, interference, code, access, multiple, division, systems, user, channel, signal, ds mobile, time, channels based, sequence, multipath,**) – focuses on DS-CDMA (Direct-Sequence Code-Division Multiple Access) systems in multipath fading channels.

(36) Cluster 8 (**ad**, **hoc**, **network**, **networks**, **mobil**, **routing**, **wireless**, **protocol**, **nodes**, **based**, **data**, **system**, **communication**, **new**, **cellular**, **hosts**,

infrastructure) – focuses on the routing protocols and infrastructure within standard ad-hoc wireless networks.

(35) Cluster 9 (**power**, **control, system**, **capacity**, **cdma**, **mobile**, **interference**, **base**, **users**, **access**, **cell**, **fading**, **station**, **cellular**, **multiple**, **link**, **systems**) – focuses on TPC (Transmit Power Control) based on signal-to-interference plus backround noise power ratio being applied under multipath fading environments.

(34) Cluster 10 (**voice**, **data**, **protocol**, **access**, **wireless**, **traffic**, **packet**, **network**, **channel**, **paper**, **delay**, **reservation**, **scheme**, **terminals throughput**, **stations**) – focuses on a Medium Access Control protocol that integrates voice and data services in wireless LANs.

(33) Cluster 11 (**diversity, systems**, **antenna, interference, system, fading, wireless, receiver, signal, multipath, multiple**, **rake**, **combining, antennas**) – focuses on antenna diversity to overcome multipath fading.

(32) Cluster 12 (**wireless**, **area**, **local**, **network**, **networks**, **systems**, **design**, **system**, **communications**, **frequency**, **wLAN**, **range**, **propagation**) – focuses on multipath propagation problems that are common within wireless local area networks.

(30) Cluster 13 (**cdma**, **receiver**, **interference**, **access**, **antenna**, **multiple**, **channel**, **time**, **signal**, **code**, **division**, **adaptive**, **error**, **power**, **systems**, **users**, **rate**) – focuses on W-CDMA (Wideband Direct Sequence Code Division Multiple Access) schemes, employing an adaptive antenna array to reduce multiple access interference.

(30) Cluster 14 (**power**, **channel**, **link**, **interference**, **fading**, **average**, **rake**, **transmit**, **cdma**, **signal**, **pilot**, **diversity**, **ber**) – focuses on the use of fast TPC (Transmit Power Control) and coherent Rake combining to improve upon DS-CDMA (Direct-Sequence Code-Division Multiple Access) schemes in increasing link capacity.

(30) Cluster 15 (**rate**, **system**, **frequency**, **interference**, **error**, **wireless**, **transmission**, **channel**, **bit**, **method**, **high**, **fading**, **multipath**) – focuses on BER (Bit Error Rate) performance in the presence of frequency-selective multipath fading channels.

(29) Cluster 16 (**channel**, **wireless**, **error**, **control**, **data**, **based**, **scheme**, **packet**, **protocol**, **access**, **protocols**, **layer**, **schemes**) – focuses on exploiting the energy between the MAC (Multiple Access Control) layer and the physical layer of a cellular wireless system. This is known as an adaptive error-control scheme.

(28) Cluster 17 (**handoff**, **cell**, **path**, **network**, **atm**, **scheme**, **mobile**, **handover**, **rerouting**, **wireless**, **paper**, **switch**, **connection**, **control**) – focuses on handoff management schemes for wireless ATM (Asynchronous Transfer Mode) networks.

(28) Cluster 18 (**protocol**, **access**, **channel**, **traffic**, **wireless**, **mac**, **multiple**, **station**, **base**, **mobile**, **reservation**, **control**, **based**, **data**) – focuses on MAC (Multiple Access Control) protocols and their performance in improving data transmission.

(26) Cluster 19 (**csma**, **cd**, **network**, **system**, **channel**, **protocol**, **delay**, **model**, **throughput**, **packet**, **persistent**) – focuses on throughput, packet delay, and packet loss rate in CSMA (Carrier-Sense Multiple Access) protocols.

(26) Cluster 20 (**access**, **wireless**, **radio**, **data**, **channel**, **throughput**, **system**, **network**, **high**, **packet**, **service**, **protocol**, **control**, **based**, **signal**, **rate**) – focuses on increasing throughput and decreasing packet loss within wireless data and radio transmissions.

(26) Cluster 21 (**routing**, **protocol**, **networks**, **ad**, **hoc**, **network**, **route**, **protocols**, **wireless**, **nodes**, **node**, **mobile**) – focuses on network routing protocols within wireless ad-hoc networks.

(26) Cluster 22 (**system**, **control**, **power**, **cdma**, **transmission**, **wireless**, **channel**, **rate**, **based**, **mobile**, **scheme**, **access**, **code**, **traffic**, **multiple**) – focuses on fast TPC (Transmit Power control) for higher-quality data transmissions with an improved BER (Bit Error Rate).

(25) Cluster 23 (**network**, **csma**, **cd**, **protocol**, **system**, **access**, **simulation**, **collision**, **multiple**, **detection**, **carrier**, **sense**, **networks**, **local**, **area**, **throughput**) – focuses on CSMA/CD (Carrier Sense Multiple Access/Collision detection) protocols to increase throughput within wireless LANs.

(24) Cluster 24 (**ghz**, **db**, **noise**, **v**, **power**, **frequency**, **voltage**, **chip**, **low**, **technology**, **supply**, **cmos**, **circuit**, **wireless**, **gain**, **dbm**, **phase**) – focuses on CMOS technology that mainly encompasses circuitry and chips.

(23) Cluster 25 (**ieee**, **wireless**, **access**, **data**, **standard**, **protocol**, **mac**, **LAN**, **mechanism**, **high**, **system**, **time**, **networks**,) – focuses on standard MAC (Medium Access Control) protocols within IEEE 802.11 wireless networks.

(23) Cluster 26 (**system**, **cdma**, **mobile**, **generation**, **services**, **systems**, **data**, **radio**, **station**, **high**, **technology**, **rate**, **wireless**) – focuses on W-CDMA (Wideband- Code-Division Multiple Access) radio transmission technologies, offering improved voice and data transmissions.

(23) Cluster 27 (**wireless**, **services**, **mobile**, **network**, **networks**, **service**, **ip**, **internet**, **data**, **systems**, **access**, **new**, **support**, **applications**) – focuses on different applications of and support for wireless mobile networks.

(22) Cluster 28 (**mobile**, **ip**, **internet**, **wireless**, **protocol**, **network**, **cellular**, **mobility**, **commerce**, **tcp**, **layer**, **new**, **data**, **multimedia**) – focuses on mobile wireless network IP (Internet Protocol) and TCP (Transmission Control Protocol) to establish a connection between two hosts for transmission of data.

(22) Cluster 29 (**tcp**, **wireless**, **link**, **throughput**, **packet**, **protocol**, **network**, **mobile**, **end**, **congestion**, **loss**, **paper**, **networks**, **layer**, **links**, **transport**) – focuses on TCP (Transmission Control Protocol) which establishes a link between a destination and a source to send and receive packets. Many factors including congestion and packet loss determine the throughput.

(22) Cluster 30 (**voice**, **data**, **packet**, **system**, **protocol**, **access**, **delay**, **time**, **traffic**, **multiple**, **wireless**, **packets**, **systems**, **integrated**) – focuses on MAC (Multiple Access Control) protocols for integrated voice and data services in wireless local networks.

(22) Cluster 31 (**network**, **ip**, **wireless**, **mobile**, **services**, **internet**, **protocol**, **networks**, **qos**, **architecture**, **support**, **service**, **management**, **data**, **mobility**) – focuses providing IP multicasting with QoS (Quality of service) support over not only wired networks, but now with wireless mobile networks as well.

(22) Cluster 32 (**wireless**, **systems**, **networks**, **mobile**, **access**, **broadband**, **atm**, **services**, **technologies**, **communications**, **future**, **network**, **high**) – focuses on broadband technoloigies being employed by wireless mobile networks to increase throughput.

(22) Cluster 33 (**traffic**, **atm**, **network**, **voice**, **networks**, **mobile**, **rate**, **delay**, **wireless**, **bit**, **access**, **bandwidth**, **paper**, **time**) – focuses on ATM (Asynchronous transfer Mode) technique in providing more efficient multimedia communications, as the demand for it has continued to increase.

(21) Cluster 34 (**fading**, **cdma**, **channel**, **diversity**, **access**, **multiple**, **code**, **error**, **mobile**, **division**, **direct**, **sequence**, **ds**, **system**, **probability**, **combining**, **scheme**, **shift**, **satellite**, **shadowing**, **phase**, **keying**) – focuses on QPSK (Quadrature Phase Shift Keying) and coherent combining in CDMA (Code-Division Multiple Access) systems to combat multipath Rayleigh fading channels.

(20) Cluster 35 (**mobile**, **network**, **location**, **wireless**, **atm**, **networks**, **scheme**, **connection**, **hlr**, **systems**, **management**, **mobility**) – focuses on HLR (Home Location Register), which stores service and location information for each mobile registered within a PCS network.

(20) Cluster 36 (**satellite**, **mobile**, **system**, **cdma**, **channel**, **systems**, **leo**, **access**, **diversity**, **link**, **power**, **capacity**, **terrestrial**, **low**, **multiple**, **communication**, **earth**, **orbit**) – focuses CDMA (Code- Division Multiple Access) protocols that have been proposed for personal communications networks for both terrestrial and satellite links.

(20) Cluster 37 (**wireless**, **network**, **access**, **networks**, **based**, **control**, **system**, **protocol**, **issues**, **time**, **mobile**, **algorithm**, **atm**, **model**, **data**, **high**, **spectrum**, **multiple**, **error**, **communications**, **broadband**) – focuses on standard protocols within a wireless ATM(Asynchronous Transfer Mode) network and the issues that these protocols deal with in transferring data.

(20) Cluster 38 (**multicast**, **mobile**, **networks**, **wireless**, **network**, **tree**, **protocol**, **based**, **routing**, **group**, **ad**, **hoc**, **multicasting**, **source**, **paper**, **nodes**) – focuses on the multicast tree problem that ad-hoc networks experience. This problem deals with two nodes within the network trying to communicate with one another.

(19) Cluster 39 (**power**, **control**, **algorithm**, **system**, **interference**, **signal**, **cdma**, **sir**, **transmission**, **systems**, **scheme**, **wireless**) – focuses on an adaptive SIR (Signal-to-Interference Ratio) based power control mechanism for CDMA (Code-Division Multiple Access) systems that provides better outage probabilities and a better response time.

(19) Cluster 40 (**mobile**, **wireless**, **radio**, **systems**, **access**, **ip**, **system**, **network**, **based**, **generation**, **services**, **internet**) – focuses on standard IP (Internet Protocol) within mobile wireless radio networks.

(18) Cluster 41 (**network**, **mobile**, **routing**, **wireless**, **algorithm**, **networks**, **based**, **time**, **mobility**, **cluster**, **ad**, **hoc**, **topology**) – focuses on the routing and topology of a standard wireless ad-hoc network.

(18) Cluster 42 (**time**, **real**, **traffic**, **access**, **protocol**, **tdma**, **wireless**, **multiple**, **communication**, **messages**, **network**, **channel**, **delay**, **protocols**) – focuses TDMA (Time-Division Multiple Access) protocols as a means of efficient wireless multimedia communications.

(18) Cluster 43(**codes**, **cdma**, **spreading**, **orthogonal**, **code**, **rate**, **turbo**, **transmission**, **system**, **data**, **time**, **frequency**, **antennas**,) focuses on a dynamic spreading code selection technique to obtain low-peak-to-average-power-ratio within a OFDM/CDMA (Orthogonal Frequency –Division Multiplexing/Code-Division Multiple Access) system

(17) Cluster 44 (**network**, **atm**, **mobile**, **wireless**, **based**, **signalling**, **architecture**, **networks**, **protocol**, **paper**, **services**, **management**, **control**) – focuses on the standard architecture within a typical ATM (Asynchronous Transfer Mode) mobile wireless network.

(17) Cluster 45 (**protocol**, **access**, **throughput**, **based**, **code**, **collision**, **wireless**, **multiple**, **delay**, **time**, **channel**, **packets**, **networks**, **receiver**, **data**) - focuses on MAC (Medium Access Control) protocol’s ability to increase throughput by avoiding packet collision while data is being transmitted through shared channels.

(16) Cluster 46 (**protocol**, **csma**, **cd**, **token**, **access**, **network**, **networks**, **ring**, **control**, **time**, **scheme**, **data**) – focuses on CSMA-CD (Carrier-Sense Multiple Access-Collision Detection and Token-ring for deadline scheduling for wireless networks.

(16) Cluster 47 (**rate**, **bit**, **wireless**, **protocol**, **time**, **atm**, **paper**, **data**, **channel**, **access**, **transmission**, **error**, **scheme**, **delay**, **techniques**) – focuses on BER (Bit Error Rate) within the transmission of wireless ATM (Asynchronous transfer Mode) networks.

(16) Cluster 48 (**arq**, **scheme**, **throughput**, **packet**, **wireless**, **channel**, **error**, **repeat**, **retransmission**, **type**, **transmission**, **rate**) – focuses on the ARQ (Automatic Repeat Request) protocol which increases throughput and decreases the number of transmitted fragmented packets by retransmitting them until they are corrected.

(15) Cluster 49 (**scheme**, **fading**, **channel**, **channels**, **wireless**, **frequency**, **error**, **equalizer**, **systems**, **paper**, **equalization**, **mode**, **ip**, **data**, **new**, **rate**) – focuses on DFE (Descision Feedback Equalization) schemes to eliminate multipath fading channels.

(15) Cluster 50 (**qos**, **time**, **service**, **policies**, **wireless**, **region**, **call**, **scheduling**, **traffic**, **access**, **admission**, **system**, **packet**, **real**, **bandwidth**) – focuses on providing QoS (Quality of Service) for mobile wireless networks through bandwidth allocation.

(15) Cluster 51 (**error**, **wireless**, **cell**, **atm**, **video**, **networks**, **loss**, **errors**, **mpeg**, **data**, **network**, **quality**, **cells**, **rate**, **layer**, **bit**,) – focuses on an ATM (Asynchronous Transfer Mode) multimedia wireless network that is efficient in video transmission with an impressive BER (Bit Error Rate).

(15) Cluster 52 (**antenna**, **ghz**, **radiation**, **microstrip**, **wireless**, **array**, **patch**, **two**, **frequency**, **LAN**, **operating**, **sons**, **impedance**, **band**, **mhz**, **dual**, **fed**, **applications**) focuses on microstrip antennas whose stable and broadside copolarized radiation patterns are satisfactory for Bluetooth application.

(16) Cluster 53 (**radio**, **system**, **mobile**, **channel**, **cdma**, **estimation**, **systems**, **joint**, **algorithm**, **detection**, **data**, **interference**, **time**,) – focuses on data estimation in the uplink of a synchronous mobile radio system applying CDMA (Code-Division Multiple Access).

(15) Cluster 54 (**rate**, **error**, **fading**, **channel**, **detection**, **data**, **cdma**, **system**, **probability**, **decoding**, **rayleigh**, **code**, **bit**, **frequency**, **transmission**, **scheme**) – focuses on BER (Bit Error Rate) performance of CDMA (Code-Division Multiple Access) schemes in multipath rayleigh fading channels.

(15) Cluster 55 (**handoff**, **call**, **scheme**, **calls**, **soft**, **channel**, **method**, **new**, **probability**, **blocking**, **systems**, **cdma**, **mobile**, **multiple**) – focuses on soft handoff techniques in DS-CDMA (Direct Sequence-Code-Division Multiple

Access) systems, providing mobile calls with seamless connections between adjacent cells.

(14) Cluster 56 (**wireless**, **link**, **internet**, **protocol**, **systems**, **protocols**, **applications**, **layer**, **links**, **tcp**, **security**, **ip**, **data**,) – focuses on problems with TCP/IP (Transmission Control Protocol/Internet Protocol) in fixed and mobile environments. Some issues include: disadvantaged links associated with bandwidth, high bit error rates, and Quality of Service.

(13) Cluster 57 (**power**, **control**, **cdma**, **fading**, **channel**, **rake**, **mobile**, **ds**, **multipath**, **rate**, **transmission**, **error**, **ber**, **frequency**, **receiver**) – focuses on the performance of CDMA (Code-Division Multiple Access) systems with the use of fast TPC (Transmit Power Control) and Rake combining, within Rayleigh fading channels.

(13) Cluster 58 (**systems**, **spread**, **multiple**, **fading**, **channel**, **wireless**, **spectrum**, **access**, **communications**, **diversity**, **multipath**, **cdma**) focuses on achieving diversity in spread-spectrum communications over fast-fading multipath channels.

(13) Cluster 59 (**power**, **protocol**, **wireless**, **energy**, **mobile**, **consumption**, **low**, **design**, **system**, **networks**, **channel**,) – focuses on a low power MAC (medium Access Control) protocol for mobile wireless networks. Low power consumption is vital as more and more mobile units are being battery powered.

(13) Cluster 60 (**protocol**, **networks**, **wireless**, **bandwidth**, **time**, **data**, **protocols**, **mobile**, **transmission**, **new**, **signaling**) – focuses on improving upon the power and bandwidth restraints present in typical mobile wireless networks.

APPENDIX 12 – PARTITIONAL CLUSTERING ELEMENTAL CLUSTERS

(26) Cluster 0 (multicast 63.9%, tree 8.3%, hoc 1.8%, host 1.5%, deliveri 1.1%, node 1.0%, mesh 0.9%, mobil 0.9%, network 0.8%, reliabl 0.8%, flood 0.7%, protocol 0.6%, rout 0.6%, migrat 0.5%, rm2 0.5%, messag 0.5%, sourc 0.5%, join 0.4%, internet 0.3%, membership 0.3%, core 0.3%, mechan 0.3%, 323 0.3%, retransmiss 0.3%, algorithm 0.2%, dynam 0.2%, multipoint 0.2%, cbt 0.2%, address 0.2%, forward 0.2%, leav 0.2%, share 0.2%, propos 0.2%, subcast 0.2%, packet 0.2%, overhead 0.1%, unicast 0.1%, cluster 0.1%, effici 0.1%, atm 0.1%) – focuses on the WMTP (Wireless Multicast Tree Problem), which occurs when two nodes within an ad-hoc network try to communicate with one another.

(68) Cluster 1 (voice 36.5%, data 6.5%, packet 5.2%, prma 4.3%, traffic 2.8%, protocol 2.5%, reserv 2.3%, integr 1.9%, termin 1.4%, access 1.1%, delai 0.8%, servic 0.8%, system 0.7%, analysi 0.7%, scheme 0.7%, isma 0.6%, transmiss 0.6%, probabl 0.6%, dynam 0.5%, propos 0.5%, channel 0.5%, perform 0.5%, multipl 0.5%, drop 0.5%, capac 0.5%, slot 0.4%, control 0.4%, evalu 0.4%, load 0.4%, cdma 0.4%, code 0.3%, call 0.3%, model 0.3%, analyz 0.3%, method 0.3%, time 0.3%, aal2 0.3%, aloha 0.3%, network 0.3%, user 0.3%) – focuses on integrated voice and data traffic in PRMA (Packet Reservation Multiple Access) schemes.

(37) Cluster 2 (call 20.8%, handoff 17.7%, probabl 6.1%, block 3.4%, drop 2.9%, resourc 2.4%, traffic 2.3%, admiss 2.2%, polici 2.1%, soft 1.8%, cac 1.6%, scheme 1.3%, method 0.9%, attempt 0.8%, cell 0.8%, cellular 0.7%, channel 0.7%, qo 0.7%, reserv 0.7%, system 0.5%, time 0.5%, region 0.5%, alloc 0.5%, cdma 0.5%, arriv 0.5%, propos 0.4%, queue 0.4%, model 0.4%, determin 0.4%, qualiti 0.4%, dynam 0.4%, capac 0.3%, hold 0.3%, util 0.3%, overload 0.3%, failur 0.3%, borrow 0.3%, reduc 0.3%, control 0.3%, network 0.3%) – focuses on different handoff management schemes and their ability to minimize dropping probability of handoff calls and blocking probability of new calls.

(57) Cluster 3 (ofdm 25.3%, frequenc 6.1%, symbol 5.1%, offset 5.1%, estim 4.5%, multiplex 2.6%, subcarri 2.6%, orthogon 2.4%, channel 1.8%, carrier 1.3%, code 1.2%, synchron 1.1%, divis 0.9%, phase 0.9%, scheme 0.8%, subchannel 0.7%, techniqu 0.7%, system 0.7%, cfo 0.7%, propos 0.7%, bluetooth 0.7%, modul 0.7%, signal 0.6%, error 0.6%, spread 0.6%, receiv

0.6%, select 0.5%, cdma 0.5%, preambl 0.5%, transmitt 0.5%, time 0.5%, rate 0.5%, multipath 0.5%, doppler 0.4%, us 0.4%, fade 0.4%, complex 0.4%, multicarri 0.4%, guard 0.4%, compens 0.4%) – focuses on the use of OFDM (Orthogonal Frequency-Division Multiplexing) to cut down on ISI (Inter-Symbol Interference) while benefiting from reduced path loss.

(69) Cluster 4 (antenna 42.7%, beam 4.5%, arrai 3.8%, radiat 2.8%, microstrip 2.0%, patch 1.6%, sector 1.3%, feed 1.2%, pattern 1.1%, ghz 0.9%, dual 0.8%, band 0.8%, circular 0.7%, indoor 0.6%, plane 0.6%, wLAN 0.5%, field 0.5%, frequenc 0.5%, design 0.5%, configur 0.5%, measur 0.5%, inc 0.4%, LAN 0.4%, monopol 0.4%, wave 0.4%, son 0.4%, john 0.4%, wilei 0.4%, imped 0.4%, ground 0.4%, planar 0.4%, degre 0.3%, adapt 0.3%, applic 0.3%, describ 0.3%, oper 0.3%, beamwidth 0.3%, port 0.3%, polar 0.3%, divers 0.3%) – focuses on microstrip antennas whose stable and broadside copolarized radiation patterns are satisfactory for Bluetooth application.

(84) Cluster 5 (power 25.3%, control 11.2%, sir 3.6%, algorithm 2.0%, tpc 2.0%, link 1.8%, fade 1.6%, outag 1.6%, interfer 1.6%, cdma 1.5%, capac 1.5%, user 1.3%, transmit 1.3%, probabl 1.1%, station 1.1%, method 0.9%, base 0.8%, signal 0.8%, system 0.8%, radio 0.8%, mobil 0.8%, ratio 0.7%, revers 0.6%, cellular 0.6%, rate 0.6%, code 0.5%, receiv 0.5%, propos 0.5%, step 0.5%, fast 0.5%, cell 0.4%, shadow 0.4%, optim 0.4%, optimum 0.4%, scheme 0.4%, rayleigh 0.4%, rake 0.4%, channel 0.4%, error 0.4%, effect 0.4%) – focuses on the use of fast TPC (Transmit Power Control) to keep SIRs (Signal-to-Interference plus backround noise Ratio) at a satisfactory level.

(111) Cluster 6 (rout 37.4%, hoc 8.6%, node 7.9%, network 3.6%, protocol 2.5%, mobil 2.0%, host 1.7%, locat 1.6%, cluster 1.4%, topolog 1.0%, algorithm 1.0%, multihop 0.8%, scheme 0.6%, manag 0.6%, connect 0.6%, packet 0.5%, dynam 0.5%, destin 0.5%, chang 0.5%, path 0.5%, manet 0.5%, inform 0.4%, zone 0.4%, agent 0.4%, distribut 0.3%, call 0.3%, pnni 0.3%, infrastructur 0.3%, flood 0.3%, posit 0.3%, base 0.3%, simul 0.3%, qo 0.3%, demand 0.2%, secur 0.2%, support 0.2%, movement 0.2%, bandwidth 0.2%, propos 0.2%, link 0.2%) – focuses on the routing and topology of a standard wireless mobile ad-hoc network.

(58) Cluster 7 (handoff 19.1%, rerout 9.5%, handov 9.3%, cell 8.0%, path 4.2%, atm 3.5%, switch 3.2%, connect 2.2%, mobil 1.8%, network 1.7%, buffer 0.9%, scheme 0.9%, architectur 0.8%, station 0.8%, optim 0.6%, manag 0.6%, pressur 0.5%, pvc 0.5%, propos 0.5%, transfer 0.5%, virtual 0.5%, servic 0.5%,

inter 0.4%, loss 0.4%, termin 0.4%, radio 0.4%, base 0.4%, ca2 0.4%, effici 0.3%, delai 0.3%, memori 0.3%, melt 0.3%, call 0.3%, support 0.3%, micromobl 0.3%, reestablish 0.2%, soft 0.2%, function 0.2%, handl 0.2%, protein 0.2%) – focuses on cell numbering to allow seamless handoffs between mobile stations and ATM (Asynchronous Transfer Mode) networks.

(107) Cluster 8 (divers 11.5%, rake 6.5%, fade 4.0%, multipath 4.0%, combin 3.8%, antenna 3.8%, receiv 3.6%, channel 2.6%, path 2.0%, coher 1.5%, branch 1.3%, interfer 1.2%, averag 1.2%, pilot 1.2%, select 1.1%, signal 1.1%, cdma 1.0%, ber 1.0%, recept 1.0%, sector 1.0%, power 0.9%, spread 0.8%, ratio 0.7%, effect 0.7%, indoor 0.6%, code 0.6%, estim 0.6%, error 0.6%, equal 0.6%, perform 0.6%, scheme 0.6%, sequenc 0.5%, system 0.5%, symbol 0.5%, direct 0.5%, gain 0.5%, us 0.5%, transmit 0.5%, multipl 0.5%, correl 0.4%) – focuses increasing throughput by the use of coherent Rake combiners within Rayleigh multipath fading channels.

(121) Cluster 9 (atm 30.2%, network 4.5%, servic 3.3%, architectur 2.7%, qos 2.6%, manag 2.4%, mobil 2.2%, support 1.7%, broadband 1.3%, wireless 1.3%, signal 1.2%, multimedia 1.2%, concept 0.9%, protocol 0.8%, connect 0.8%, switch 0.8%, design 0.6%, capabl 0.6%, termin 0.6%, awa 0.6%, articl 0.6%, isdn 0.5%, user 0.5%, issu 0.5%, transport 0.5%, function 0.5%, provid 0.5%, technolog 0.5%, control 0.5%, access 0.4%, locat 0.4%, integr 0.4%, resourc 0.4%, describ 0.4%, infrastructur 0.4%, implement 0.4%, discuss 0.4%, qualiti 0.4%, system 0.4%, call 0.4%) – focuses on maintaining guaranteed levels of QoS (Quality of Service) within wireless ATM (Asynchronous Transfer Mode) networks.

(96) Cluster 10 (tcp 10.1%, arq 6.6%, error 5.8%, cell 4.3%, atm 3.0%, packet 2.6%, scheme 2.5%, link 2.5%, video 2.2%, fec 2.2%, control 2.1%, loss 2.0%, layer 2.0%, retransmiss 1.3%, throughput 1.3%, protocol 1.3%, congest 1.2%, rate 1.1%, transmiss 1.0%, repeat 0.9%, data 0.8%, mpeg 0.8%, network 0.7%, header 0.7%, propos 0.7%, correct 0.7%, channel 0.6%, bit 0.6%, stream 0.6%, wireless 0.6%, mechan 0.6%, acknowledg 0.6%, transport 0.6%, protect 0.5%, request 0.5%, transfer 0.5%, code 0.5%, perform 0.5%, adapt 0.4%, recoveri 0.4%) – focuses on the performance of TCP (Transmission Control Protocols) employing ARQ/FEC (Automatic Repeat Request/Forward Error Correction) protocols, to cut down on packet error.

(119) Cluster 11 (traffic 9.2%, protocol 4.8%, mac 4.4%, alloc 3.5%, schedul 2.8%, servic 1.9%, resourc 1.8%, tdma 1.6%, prioriti 1.5%, real 1.5%, access

1.5%, dynam 1.5%, time 1.5%, atm 1.4%, qos 1.4%, class 1.4%, propos 1.4%, slot 1.3%, multimedia 1.3%, packet 1.3%, algorithm 1.3%, assign 1.2%, scheme 1.2%, control 1.2%, delai 1.0%, bandwidth 1.0%, channel 0.9%, base 0.8%, throughput 0.8%, qualiti 0.8%, reserv 0.7%, effici 0.7%, request 0.7%, fair 0.6%, medium 0.6%, load 0.6%, network 0.6%, wireless 0.6%, rate 0.6%, transmiss 0.6%) – focuses on MAC (Medium Access Control) Protocols that efficiently accommodate real-time voice and video traffic in employing suboptimal resource allocation.

(80) Cluster 12 (802 12.4%, protocol 9.8%, ieee 9.4%, mac 4.7%, ethernet 2.5%, real 1.8%, time 1.7%, standard 1.4%, station 1.1%, network 1.1%, wLAN 1.0%, dcf 1.0%, data 1.0%, LAN 0.9%, throughput 0.9%, energi 0.9%, packet 0.8%, save 0.8%, layer 0.8%, backoff 0.7%, model 0.7%, hidden 0.7%, frame 0.7%, control 0.7%, medium 0.6%, traffic 0.6%, delai 0.6%, access 0.5%, specif 0.5%, mechan 0.5%, coordin 0.5%, termin 0.5%, csma 0.5%, power 0.5%, tune 0.5%, transmiss 0.5%, channel 0.4%, commun 0.4%, wireless 0.4%, content 0.4%) – focuses on standard MAC (Medium Access Control) protocols for IEEE 802.11 wireless LANs.

(147) Cluster 13 (csma 14.8%, protocol 8.6%, collis 5.1%, throughput 3.8%, packet 2.8%, delai 2.3%, LAN 1.8%, model 1.8%, aloha 1.7%, channel 1.7%, sens 1.6%, network 1.5%, token 1.4%, persist 1.3%, load 1.3%, messag 1.3%, bu 1.3%, access 1.3%, station 1.1%, analysi 0.9%, perform 0.9%, time 0.8%, ring 0.8%, slot 0.8%, detect 0.6%, retransmiss 0.6%, analyz 0.6%, transmiss 0.5%, traffic 0.5%, resolut 0.5%, result 0.5%, markov 0.5%, carrier 0.5%, queue 0.5%, local 0.5%, stabil 0.4%, probabl 0.4%, obtain 0.4%, base 0.4%, random 0.4%) – focuses on CSMA (Sarrier-Sense Multiple Access) protocols that increase throughput in focusing on packet collision avoidance.

(135) Cluster 14 (estim 7.1%, channel 4.4%, interfer 3.6%, receiv 3.5%, detector 3.3%, cancel 2.5%, adapt 2.4%, multius 2.3%, equal 2.2%, algorithm 2.2%, multipath 1.9%, signal 1.7%, fade 1.6%, blind 1.4%, cdma 1.4%, filter 1.3%, dfe 1.1%, user 1.0%, time 0.9%, decis 0.9%, complex 0.9%, train 0.8%, arrai 0.8%, process 0.8%, suppress 0.8%, propos 0.8%, sequenc 0.8%, perform 0.7%, antenna 0.7%, symbol 0.7%, error 0.7%, code 0.7%, space 0.7%, multipl 0.6%, squar 0.6%, decorrel 0.5%, system 0.5%, detect 0.5%, method 0.5%, approach 0.5%) – focuses on multiuser detectors for cochannel interference cancellation, developed by computing fixed-lag MAP (Maximum A Posteriori) estimates of the data symbols of the desired user.

(155) Cluster 15 (amplifi 5.3%, ghz 5.0%, power 3.7%, filter 3.2%, modul 2.8%, chip 2.8%, frequenc 2.6%, circuit 2.5%, voltag 2.2%, digit 1.7%, mhz 1.6%, signal 1.6%, band 1.6%, suppli 1.5%, nois 1.4%, low 1.3%, integr 1.3%, design 1.3%, oscil 1.2%, phase 1.2%, dbm 1.2%, cmos 1.2%, spectrum 1.1%, analog 1.0%, output 0.9%, modem 0.8%, rang 0.8%, technolog 0.7%, transceiv 0.7%, receiv 0.7%, spread 0.7%, fabric 0.6%, devic 0.6%, applic 0.5%, implement 0.5%, compon 0.5%, oper 0.5%, vco 0.5%, nonlinear 0.4%, local 0.4%) – focuses on different aspects of the CMOS hardware or circuitry incorporated in wireless technology.

(145) Cluster 16 (code 9.3%, error 4.7%, rate 4.0%, bit 2.9%, fade 2.9%, spread 2.7%, channel 2.6%, turbo 2.3%, decod 2.1%, scheme 2.1%, sequenc 2.0%, cdma 1.8%, modul 1.5%, orthogon 1.4%, hop 1.3%, system 1.2%, transmiss 1.1%, frequenc 1.0%, rayleigh 1.0%, multipath 0.9%, perform 0.8%, multipl 0.8%, ber 0.8%, select 0.6%, divis 0.6%, divers 0.6%, receiv 0.6%, techniqu 0.6%, improv 0.6%, time 0.5%, shift 0.5%, transmit 0.5%, result 0.5%, direct 0.5%, propos 0.5%, spectrum 0.5%, detect 0.5%, symbol 0.4%, data 0.4%, combin 0.4%) – focuses on the use of DS\CDMA (Direct-Sequence\Code-Division Multiple Access) systems that improve BER (Bit Error Rate) within Rayleigh multipath fading channels.

(95) Cluster 17 (bluetooth 13.4%, standard 5.3%, devic 4.3%, 802 3.1%, ieee 3.0%, wLAN 2.7%, technolog 2.4%, design 1.8%, product 1.5%, test 1.3%, LAN 1.3%, articl 1.2%, wireless 1.2%, develop 1.2%, cost 1.2%, network 1.1%, market 1.0%, home 0.9%, band 0.8%, local 0.8%, low 0.8%, electron 0.8%, discuss 0.8%, data 0.8%, radio 0.8%, layer 0.8%, power 0.7%, ghz 0.7%, connect 0.7%, person 0.7%, ethernet 0.7%, commun 0.7%, describ 0.6%, equip 0.6%, speed 0.6%, system 0.6%, interoper 0.6%, sensor 0.5%, hiperLAN 0.5%, interfac 0.5%) – focuses on standard Bluetooth IEEE 802.11 wireless LAN technology.

(178) Cluster 18 (cdma 11.7%, capac 6.2%, code 3.1%, system 3.0%, interfer 2.9%, cell 2.6%, divis 2.5%, satellit 2.4%, user 1.9%, multipl 1.6%, link 1.4%, acquisit 1.3%, cellular 1.1%, mobil 1.1%, access 1.0%, signal 1.0%, techniqu 0.9%, channel 0.9%, spread 0.9%, downlink 0.9%, spectrum 0.8%, frequenc 0.8%, radio 0.8%, power 0.8%, uplink 0.8%, tdd 0.7%, station 0.7%, detect 0.6%, antenna 0.6%, shown 0.6%, direct 0.6%, time 0.6%, synchron 0.5%, search 0.5%, sequenc 0.5%, commun 0.5%, receiv 0.5%, tdma 0.5%, consid 0.5%, spectral 0.5%) – the use of CDMA (Code-Division Multiple Access) systems in satellite communications.

(74) Cluster 19 (optic 6.8%, indoor 4.6%, wave 3.5%, reflect 3.1%, build 2.3%, column 2.2%, wall 2.1%, method 1.4%, propag 1.4%, measur 1.4%, laser 1.3%, calcul 1.3%, characterist 1.2%, pressur 1.1%, temperatur 1.0%, multipath 0.9%, floor 0.9%, oxygen 0.9%, quartz 0.9%, phase 0.8%, transmitt 0.8%, trace 0.8%, predict 0.7%, fiber 0.7%, rai 0.7%, offic 0.7%, environ 0.7%, signal 0.7%, degre 0.6%, millimet 0.6%, system 0.6%, us 0.6%, materi 0.5%, microwav 0.5%, sfc 0.5%, lo 0.5%, model 0.5%, delai 0.5%, rang 0.5%, increas 0.5%) – focuses on indoor infrared wireless systems in the field of fiber optical networks.

(233) Cluster 20 (servic 6.1%, internet 5.8%, mobil 3.8%, network 3.2%, technolog 3.2%, protocol 1.9%, develop 1.6%, wireless 1.5%, system 1.4%, commun 1.4%, support 1.4%, applic 1.3%, provid 1.3%, secur 1.2%, layer 1.0%, futur 1.0%, gener 1.0%, broadband 0.9%, articl 0.8%, issu 0.8%, access 0.8%, multimedia 0.8%, architectur 0.8%, infrastructur 0.8%, tcp 0.8%, user 0.8%, video 0.7%, describ 0.7%, discuss 0.7%, data 0.7%, telecommun 0.7%, project 0.6%, person 0.6%, platform 0.6%, research 0.6%, standard 0.5%, current 0.5%, authent 0.5%, global 0.5%, comput 0.5%) – focuses on a number of different services and protocols becoming available in current mobile telecommunication networks.

APPENDIX 13 – SEMINAL PAPERS OF WIRELESS LANs LITERATURE

ABSTRACT

A chronically weak area in research papers, reports, and reviews is the complete identification of seminal background documents that formed the building blocks for these papers. A method for systematically determining these seminal references is presented. Citation-Assisted Background (CAB) is based on the assumption that seminal documents tend to be highly cited. Application of CAB to the field of Wireless LANs research is presented. While CAB is a highly systematic approach for identifying seminal references, it serves as a supplement and is not a substitute for the judgment of the authors.

INTRODUCTION

Research is a method of systematically exploring the unknown to acquire knowledge and understanding. Efficient research requires awareness of all prior research and technology that could impact the research topic of interest, and builds upon these past advances to create discovery and new advances. The importance of this awareness of prior art is recognized throughout the research community. It is expressed in diverse ways, including requirements for Background sections in journal research articles, invited literature surveys in targeted research areas, and required descriptions of prior art in patent applications.

For the most part, development of Background material for any of the above applications is relatively slow and labor intensive, and limited in scope. Background material development usually involves some combination of manually sifting through outputs of massive computer searches, manually tracking references through multiple generations, and searching one's own records for personal references. The few studies that have been done on the adequacy of Background material in documents show that only a modest fraction of relevant material is included (e.g., MacRoberts and MacRoberts, 1989, 1996; Liu, 1993).

Typically missing from standard Background section or review article development, as well as in the specific examples cited above, is a systematic approach for identifying the key documents and events that provided the groundwork for the research topic of interest. The present appendix presents such a systematic approach for identifying the key documents, called Citation-Assisted Background (CAB), and applies it to the area of Wireless LANs research.

Every published research review on Wireless LANs typically covers a limited subset of the technology rather than the total discipline. None of these published reviews has the spatial and temporal breadth of coverage of the present report, none uses a query of the extent and complexity of the present report, and none uses the systematic approach described here to insure that all highly cited articles related to the discipline of interest are identified. In the main body of the present report, we used text mining techniques to query the open literature to uncover the infrastructure of Wireless LANs publications. In the present appendix, we describe a systematic approach to insure that all highly cited seminal articles related to Wireless LANs are identified. The technique is used to demonstrate the utility of the CAB approach.

CONCEPT DESCRIPTION

The CAB concept [Kostoff and Shlesinger, 2005d] identifies the seminal Background documents for a research area using citation analysis. CAB rests on the assumption that a seminal document for a specific research area will typically have been referenced positively by a substantial number of people who are active researchers in that specific area. Implementation of the CAB concept then requires the following steps:

- The research area of interest must be defined clearly
- The documents that define the area of interest must be identified and retrieved
- The references most frequently used in these documents must be identified and selected
- These critical references must be analyzed, and integrated in a cohesive narrative manner to form a comprehensive Background section or separate literature survey

These required steps are achieved in the following manner.

- The research topic of interest is defined clearly by the researchers who are documenting their study results. In the present study, this definition was presented in the Introduction.
- The topical definition is sharpened further by the development of a literature retrieval query. In the present study, the detailed query was presented in the Introduction.
- The query is entered into a database search engine, and documents relevant to the topic are retrieved. In the present appendix, 6230 research articles were retrieved from the Web version of the Science Citation Index (SCI) for the years 1991 to mid-2005. The SCI was used because it is the only major research database to contain references, in a readily extractable format.
- These documents are combined to create a separate database, and all the references contained in these documents are extracted. Identical references are combined, the number of occurrences of each reference is tabulated, and a table of references and their occurrence frequencies is constructed. In the present text mining study, separate references with frequencies of two or greater were extracted and tabulated. Table A13-1 contains the ten highest frequency (most cited) references extracted from the Wireless LANs database.

TABLE A13-1 – TEN MOST HIGHLY CITED DOCUMENTS – 1991-2005

AUTHOR	YEAR	SOURCE	VOLUME	PAGE	#CIT
GILHOUSEN KS	1991	IEEE T VEH TECHNOL	V40	P303	212
PROAKIS JG	1995	DIGITAL COMMUNICATIO			154
JAKES WC	1974	MICROWAVE MOBILE COM			134
JOHNSON DB	1996	MOBILE COMPUTING	P153		133
PERKINS CE	1999	P 2 IEEE WORKSH MOB	P90		121
VITERBI AJ	1995	CDMA PRINCIPLES SPRE			114
RAPPAPORT TS	1996	WIRELESS COMMUNICATI			110
BROCH J	1998	P 4 ANN ACM IEEE INT	P85		108
RAYCHAUDHURI D	1994	IEEE J SEL AREA COMM	V12	P1401	104
GOODMAN DJ	1989	IEEE T COMMUN	V37	P885	98

Two frequencies are computed for each reference, but only the first is shown in Table A13-1. The frequency shown in the rightmost column is the number of times each reference was cited by the 6230 records in the retrieved database only. This number reflects the importance of a given reference to the specific discipline of Wireless LANs. The second frequency number (not shown) is the total number of citations the reference received from all sources in all years after publication, and reflects the importance of a given reference to all the fields of science that cited the reference. This second number is obtained from the citation field or citation window in the SCI. In CAB, only the first frequency is used, since it is topic-specific. Using the first discipline-specific frequency number obviates the need to normalize citation frequencies for different disciplines (due to different levels of activity in different disciplines), as would be the case if total citation frequencies were used to determine the ordering of the references.

CONCEPT IMPLEMENTATION

To identify the total candidate references for the Background section, a table similar in structure to Table A13-1, but containing all the references from the retrieved records, is constructed. A threshold frequency for selection can be determined by arbitrary inspection (e.g.., a Background section consisting of 150 key references is arbitrarily selected). The first author has found a dynamic selection process more useful. In this dynamic process, references are selected, analyzed, and grouped based on their order in the citation frequency table until the resulting Background is judged sufficiently complete by the Background developers.

To insure that the influential documents published both long ago and very recently are included, the following total process is used. The reference frequency table is ordered by inverse frequency, as above, and a high value of the selection frequency threshold is selected initially. Documents with citations above this frequency are tagged. Then, the table is re-ordered chronologically. The early historical documents with citation frequencies substantially larger than those of their contemporaries are selected, as are the extremely recent documents with citation frequencies substantially larger than those of their contemporaries. By contemporaries, it is meant documents published in the same time frame, not limited to the same year (see next paragraph for examples of how we implement 'same time frame'). Then, the dynamic selection process defined above is applied to the early historical references, the intermediate time references (those falling under the high frequency threshold), and the extremely recent references (approximately two years or less).

Table A13-2 contains the final references selected for the Wireless LANs Background survey. The first reference listed, Shannon's paper(s) on the mathematical theory of communication, had many more citations than any paper published in the 1900s, up to Price's paper in 1958. Specifically, from the early 1900s to 1957, the next most cited paper had five citations. In turn, Price's paper had more citations than any published previously, or those published until Gilbert's paper in 1960. Specifically, from 1958 to 1960, the next most cited paper had nine citations. This is a graphic example of how we interpret a paper's having substantially more citations than its contemporaries. We do not constrain ourselves with a numerical threshold, but rather interpret the total citation pattern within a given time frame.

TABLE A13-2 – SEMINAL DOCUMENTS SELECTED FOR INCLUSION IN BACKGROUND

AUTHOR	YEAR	SOURCE	VOLUME	PAGE	#CITES
SHANNON CE	1948	BELL SYST TECH J	V27	P379	10
SHANNON CE	1948	BELL SYST TECH J	V27	P623	5
SHANNON CE	1949	P IRE	V37	P10	5
PRICE R	1958	P IRE	V46	P555	24
GILBERT EN	1960	BELL SYST TECH J	V39	P1253	38
LITTLE JDC	1961	OPER RES	V9	P383	10
BELLO PA	1963	IRE T COMMUN SYST	V11	P360	37
SCHWARTZ M	1966	COMMUNICATION SYSTEM			23
CHANG RW	1966	BELL SYST TECH J	V45	P1775	16

CLARKE RH	1968	BELL SYST TECH J	V47	P957	12
BRADY PT	1968	BELL SYST TECH J	V47	P73	12
BRADY PT	1969	BELL SYST TECH J	V48	P2445	27
ABRAMSON N	1970	P FALL JOINT COMP C	V37	P281	23
WEINSTEIN SB	1971	IEEE T COMMUN TECHNO	V19	P628	38
JAKES WC	1974	MICROWAVE MOBILE COM			134
TOBAGI FA	1975	IEEE T COMMUN	V23	P1417	84
KLEINROCK L	1975	IEEE T COMMUN	V23	P1400	75
KLEINROCK L	1975	QUEUEING SYSTEMS	V1		55
KLEINROCK L	1975	IEEE T COMMUN	V23	P410	19
METCALFE RM	1976	COMMUN ACM	V19	P395	28
DIFFIE W	1976	IEEE T INFORM THEORY	V22	P644	20
PURSLEY MB	1977	IEEE T COMMUN	V25	P795	72
COOPER GR	1978	IEEE T VEH TECHNOL	V27	P264	19
GFELLER FR	1979	P IEEE	V67	P1474	36
CAPETANAKIS JI	1979	IEEE T INFORM THEORY	V25	P505	24
TOBAGI FA	1980	COMPUT NETWORKS	V4	P245	34
TURIN GL	1980	P IEEE	V68	P328	30
BAKER DJ	1981	IEEE T COMMUN	V29	P1694	20
RAYCHAUDHURI D	1981	IEEE T COMMUN	V29	P895	20
PICKHOLTZ RL	1982	IEEE T COMMUN	V30	P855	23
LIN S	1983	ERROR CONTROL CODING			52
TAKAGI H	1984	IEEE T COMMUN	V32	P246	25
CIMINI LJ	1985	IEEE T COMMUN	V33	P665	55
VERDU S	1986	IEEE T INFORM THEORY	V32	P85	48
SALEH AAM	1987	IEEE J SEL AREA COMM	V5	P128	45
EPHREMIDES A	1987	P IEEE	V75	P56	38
BERTSEKAS D	1987	DATA NETWORKS			36
JUBIN J	1987	P IEEE	V75	P21	33
HAGENAUER J	1988	IEEE T COMMUN	V36	P389	25
GOODMAN DJ	1989	IEEE T COMMUN	V37	P885	98
PROAKIS JG	1989	DIGITAL COMMUNICATIO			96
LUPAS R	1989	IEEE T INFORM THEORY	V35	P123	37
KARN P	1990	P ARRL CRRL AM RAD 9 C	P134		52
BINGHAM JAC	1990	IEEE COMMUN MAG	V28	P5	40
VARANASI MK	1990	IEEE T COMMUN	V38	P509	36
LUPAS R	1990	IEEE T COMMUN	V38	P496	35
GILHOUSEN KS	1991	IEEE T VEH TECHNOL	V40	P303	212
LEE WCY	1991	IEEE T VEH TECHNOL	V40	P291	66

NANDA S	1991	IEEE T VEH TECHNOL	V40	P584	47
PICKHOLTZ RL	1991	IEEE T VEH TECHNOL	V40	P313	40
GOODMAN DJ	1991	IEEE T VEH TECHNOL	V40	P170	39
BERTSEKAS D	1992	DATA NETWORKS			79
ZANDER J	1992	IEEE T VEH TECHNOL	V41	P57	32
MOULY M	1992	GSM SYSTEM MOBILE CO			32
VITERBI AM	1993	IEEE J SEL AREA COMM	V11	P892	54
HASHEMI H	1993	P IEEE	V81	P943	39
YEE N	1993	P IEEE PIMRC 93 YOK	P109		32
ARIYAVISITAKUL S	1993	IEEE T COMMUN	V41	P1626	31
RAYCHAUDHURI D	1994	IEEE J SEL AREA COMM	V12	P1401	104
PERKINS CE	1994	P ACM SIGCOMM 94 LON	P234		86
STEVENS WR	1994	TCP IP ILLUSTRATED	V1		59
BHARGHAVAN V	1994	P ACM SIGCOMM 94	P212		57
ACAMPORA AS	1994	IEEE J SEL AREA COMM	V12	P1365	56
BAIER A	1994	IEEE J SEL AREA COMM	V12	P733	56
WINTERS JH	1994	IEEE T COMMUN	V42	P1740	34
MADHOW U	1994	IEEE T COMMUN	V42	P3178	34
MOOSE PH	1994	IEEE T COMMUN	V42	P2908	33
JAKES WC	1994	MICROWAVE MOBILE COM			31
ARIYAVISITAKUL S	1994	IEEE T COMMUN 1	V42	P597	30
PROAKIS JG	1995	DIGITAL COMMUNICATIO			154
VITERBI AJ	1995	CDMA PRINCIPLES SPRE			114
CACERES R	1995	IEEE J SEL AREA COMM	V13	P850	43
KOHNO R	1995	IEEE COMMUN MAG	V33	P58	42
PAHLAVAN K	1995	WIRELESS INFORMATION			40
GERLA M	1995	ACM BALTZER J WIRELE	V1	P255	39
BAKRE A	1995	P 15 INT C DISTR COM	P136		35
HONIG M	1995	IEEE T INFORM THEORY	V41	P944	34
YATES RD	1995	IEEE J SEL AREA COMM	V13	P1341	33
GERLA M	1995	WIREL NETW	V1	P255	32
JOHNSON DB	1996	MOBILE COMPUTING	P153		133
RAPPAPORT TS	1996	WIRELESS COMMUNICATI			110
FOSCHINI GJ	1996	BELL LABS TECH J	V1	P41	44
MURTHY S	1996	ACM BALTZER MOBILE N	V1	P183	38
ADACHI F	1996	IEICE T COMMUN EB	V79	P1316	36
PERKINS C	1996	2002 RFC			31
JOHNSON DB	1996	MOBILE COMPUTING			30
*IEEE	1997	80211 IEEE			91

LIN CHR	1997	IEEE J SEL AREA COMM	V15	P1265	62
BALAKRISHNAN H	1997	IEEE ACM T NETWORK	V5	P756	59
PARK VD	1997	P IEEE INFOCOM 97 KO	P1405		51
RAYCHAUDHURI D	1997	IEEE J SEL AREA COMM	V15	P83	47
HARA S	1997	IEEE COMMUN MAG	V35	P126	43
TOH CK	1997	WIRELESS PERS COMMUN	V4	P103	39
CROW BP	1997	IEEE COMMUN MAG	V35	P116	36
KAHN JM	1997	P IEEE	V85	P265	30
CHIANG CC	1997	P IEEE SICON 97 APR	P197		30
*IEEE	1997	802111997 IEEE			30
BROCH J	1998	P 4 ANN ACM IEEE INT	P85		108
TAROKH V	1998	IEEE T INFORM THEORY	V44	P744	75
ALAMOUTI SM	1998	IEEE J SEL AREA COMM	V16	P1451	64
VERDU S	1998	MULTIUSER DETECTION			62
ADACHI F	1998	IEEE COMMUN MAG	V36	P56	58
FOSCHINI GJ	1998	WIRELESS PERS COMMUN	V6	P311	56
KO YB	1998	P ACM IEEE MOBICOM 9	P66		48
DAHLMAN E	1998	IEEE COMMUN MAG	V36	P70	41
LI Y	1998	IEEE T COMMUN	V46	P902	39
SINGH S	1998	P 4 ANN ACM IEEE INT	P181		33
SEO S	1998	IEICE T COMMUN EB	V81	P1508	33
PERKINS CE	1999	P 2 IEEE WORKSH MOB	P90		121
ROYER EM	1999	IEEE PERS COMMUN	V6	P46	68
VANNEE R	1999	IEEE COMMUN MAG	V37	P82	42
RODOPLU V	1999	IEEE J SEL AREA COMM	V17	P1333	40
ROYER EM	1999	IEEE PERSONAL CO APR	P46		39
SOBRINHO JL	1999	IEEE J SEL AREA COMM	V17	P1353	38
TAROKH V	1999	IEEE T INFORM THEORY	V45	P1456	38
NI SY	1999	P 5 ANN ACM IEEE INT	P151		36
*IEEE	1999	80211A IEEE			36
IWATA A	1999	IEEE J SEL AREA COMM	V17	P1369	35
LIN CHR	1999	IEEE J SEL AREA COMM	V17	P1426	35
LI Y	1999	IEEE J SEL AREA COMM	V17	P461	35
ZHOU LD	1999	IEEE NETWORK	V13	P24	33
GUPTA P	2000	IEEE T INFORM THEORY	V46	P388	81
BIANCHI G	2000	IEEE J SEL AREA COMM	V18	P535	77
CALI F	2000	IEEE ACM T NETWORK	V8	P785	49
VANNEE R	2000	OFDM WIRELESS MULTIM			45
HAARTSEN JC	2000	IEEE PERS COMMUN	V7	P28	37

PERKINS CE	2001	AD HOC NETWORKING			36
XU SG	2001	IEEE COMMUN MAG	V39	P130	30
AKYILDIZ IF	2002	COMPUT NETW	V38	P393	23
JOHNSON DB	2003	DYNAMIC SOURCE ROUTI			13
XUE F	2004	WIREL NETW	V10	P169	6
JOHNSON D	2004	3775 RFC			6

There were a total of 133 documents selected as seminal. While the earliest seminal documents in the physical sciences literatures we have examined previously were published in the 18th and 19th centuries, the earliest document identified in the present Wireless LANs analysis is Shannon's classic 1948 paper(s) on the mathematical theory of communication.

Although the journals listed in Table A13-2 cover many aspects of communication, three stand out in terms of numbers of seminal papers published. From 1948-1969 (with an outlier in 1996), the Bell System Technical Journal published eight of these seminal papers. From 1975-1994 (with an outlier in 1998), the IEEE Transactions on Communications published 19 of these seminal papers. From 1993-2000 (with an outlier in 1987), the IEEE Journal on Selected Areas in Communications published 15 of these seminal papers.

Each of these three journals commanded essentially a separate time frame, with each time frame appearing approximately sequentially.

APPENDIX 14 – IMPORTANT KEYWORDS

For this appendix, 6230 records were retrieved covering 1991 to mid-2005, and the highest frequency Keywords were extracted. The very highest frequency Keywords are quite generic, whereas the lowest frequency Keywords on this list become quite specific. These data allow the reader to generate a manual taxonomy based on the reader's perception of the structure of the Wireless LANs literature, with the high frequency phrases defining the top level categories and the low frequency phrases populating the pre-determined categories. These Keyword data also allow the reader to construct his/ her query for retrieving selected literatures of personal interest.

KEYWORD	FREQ
PERFORMANCE	320
SYSTEMS	255
WIRELESS LAN	252
AD HOC NETWORKS	227
NETWORKS	221
CDMA	220
WIRELESS NETWORKS	204
CAPACITY	171
CHANNELS	161
BLUETOOTH	150
SYSTEM	132
OFDM	120
WIRELESS	115
DIVERSITY	105
WLAN	104
FADING CHANNELS	101
PERFORMANCE ANALYSIS	95
DS-CDMA	94
WIRELESS ATM	93
COMMUNICATION	93
IEEE 802.11	91
PROTOCOL	91
DESIGN	89
WIRELESS COMMUNICATIONS	89
PERFORMANCE EVALUATION	88
POWER CONTROL	88
AD HOC NETWORK	85
ROUTING	82
PROTOCOLS	78
QUALITY OF SERVICE	77
TCP	76
ACCESS	75
CHANNEL ESTIMATION	74

RADIO	71
QOS	69
MOBILE AD HOC NETWORKS	65
THROUGHPUT	64
MOBILE RADIO	63
MULTIPLE-ACCESS	61
ARCHITECTURE	61
CHANNEL	60
ATM	60
MOBILE	58
MOBILE COMPUTING	58
SIMULATION	57
EQUALIZATION	56
WIRELESS COMMUNICATION	55
MOBILITY	54
RECEIVER	54
INTERNET	53
MULTIUSER DETECTION	53
MOBILE COMMUNICATIONS	52
CODE DIVISION MULTIPLE ACCESS	49
ALGORITHM	48
CODES	47
WIRELESS NETWORK	47
HANDOFF	46
PACKET RADIO NETWORKS	46
WIRELESS LANS	46
TRANSMISSION	45
MULTIMEDIA	45
SPREAD-SPECTRUM	44
CMOS	44
MANET	43
MODULATION	42
MOBILE IP	42
SCHEDULING	40
MULTICAST	40
ALGORITHMS	40
WIRELESS AD HOC NETWORKS	39
SPREAD SPECTRUM	39
POWER-CONTROL	39
SENSE MULTIPLE-ACCESS	39
ANTENNAS	38
MEDIUM ACCESS CONTROL	38
CELLULAR CDMA	38
MODEL	38
INTERFERENCE SUPPRESSION	37
MAC	37
WIRELESS LOCAL AREA NETWORK (WLAN)	36
MAC PROTOCOL	36

TDMA	36
SECURITY	35
PROPAGATION	35
UMTS	34
MOBILITY MANAGEMENT	33
SENSOR NETWORKS	33
RADIO CHANNELS	32
INTERFERENCE	32
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